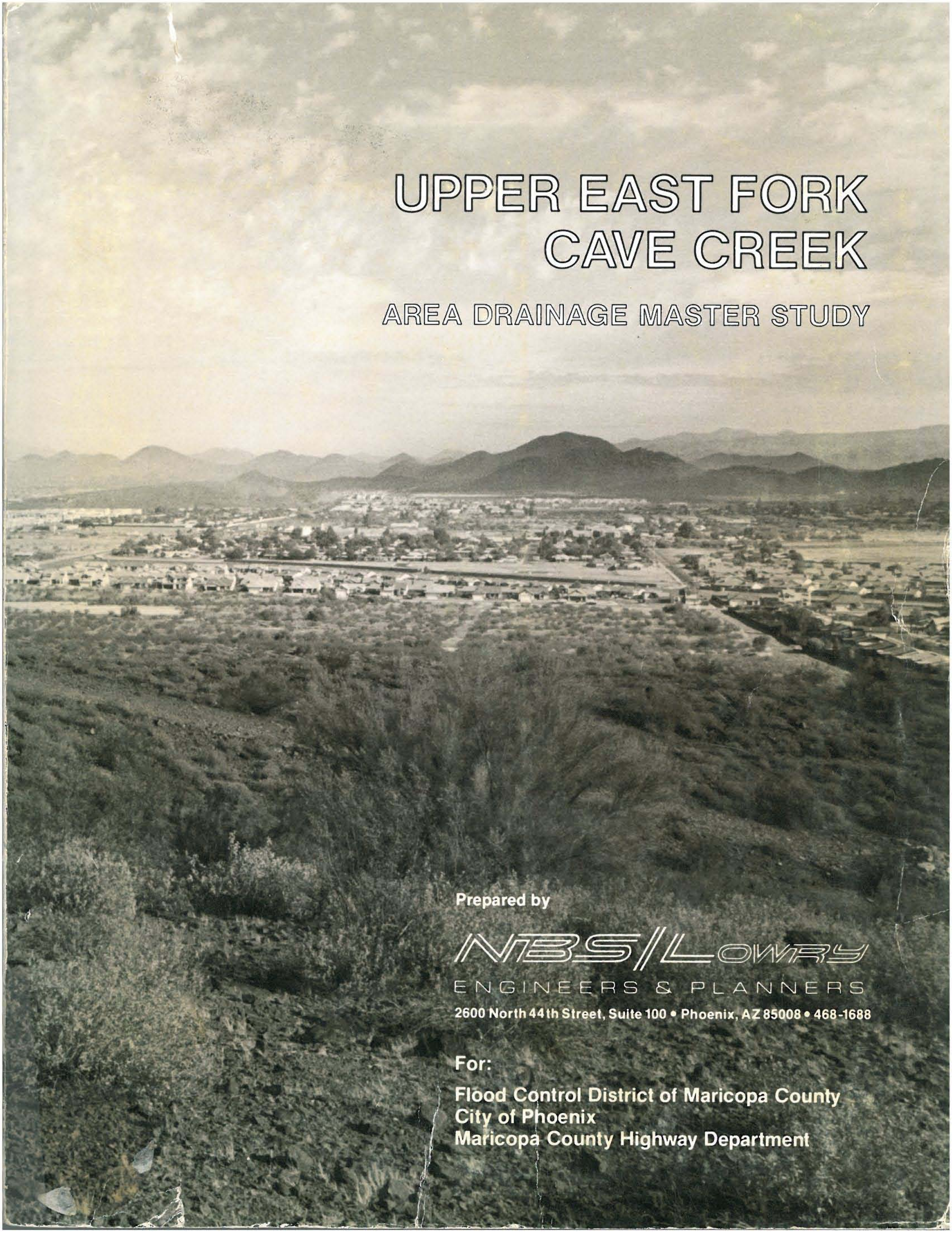

UPPER EAST FORK CAVE CREEK

AREA DRAINAGE MASTER STUDY

Prepared by

NBS/LOWRY
ENGINEERS & PLANNERS

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For:

Flood Control District of Maricopa County
City of Phoenix
Maricopa County Highway Department

UPPER EAST FORK CAVE CREEK
AREA DRAINAGE MASTER STUDY

PREPARED FOR:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

CITY OF PHOENIX

MARICOPA COUNTY HIGHWAY DEPARTMENT

Registered Professional Engineer
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NBS/LOWRY

OCTOBER 1987

UPPER EAST FORK CAVE CREEK AREA DRAINAGE MASTER STUDY

EXECUTIVE SUMMARY

ABSTRACT

This report on the Upper East Fork Cave Creek Area Drainage Master Study has been prepared for the Flood Control District of Maricopa County, the City of Phoenix, and the Maricopa County Highway Department to achieve the following objectives:

1. To document the status of existing runoff and flooding conditions in a 16 square mile study area shown on Figure 1.1.

2. To identify and evaluate alternatives for providing 100-year flood protection.

3. To identify improvements needed to implement the recommended alternative.

4. To develop cost estimates and preliminary engineering design data for the proposed flood protection plan.

To meet the first of these objectives, runoff modelling was performed using the Soil Conservation Service TR-20 runoff synthesis model. Using this model, 100-year, 50-year and 10-year flood hydrographs were synthesized throughout the study area. Because Upper East Fork Cave Creek is within an alluvial fan which is characterized by numerous small drainage features which approximate an overland flow condition, a two dimensional diffusion model was applied as an aid in delineating overland flow paths. The final watershed model was found to produce results closely matching results of previous FEMA studies at the outlet of the Upper East Fork Cave Creek watershed.

UPPER EAST FORK - CAVE CREEK AREA DRAINAGE MASTER STUDY

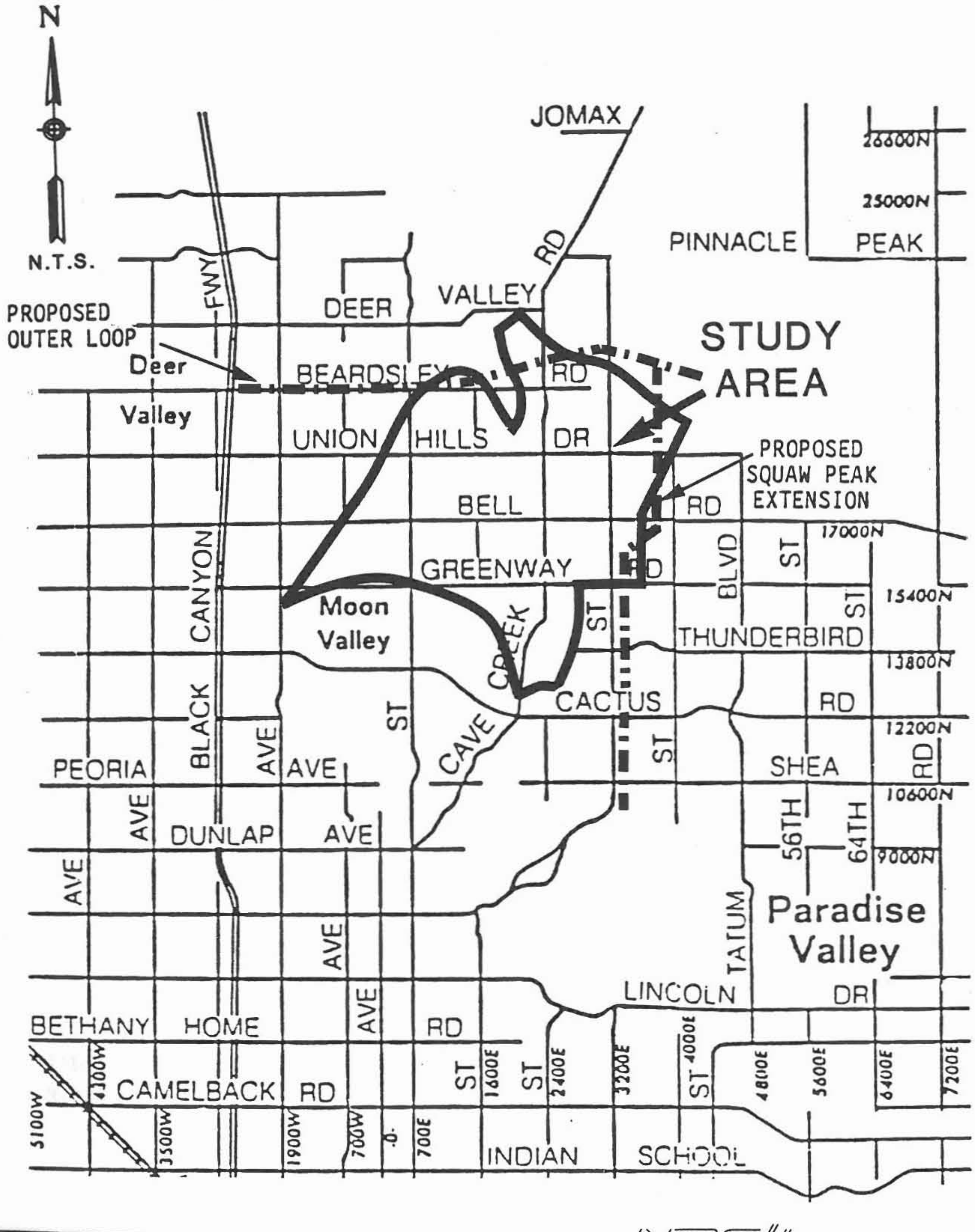

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FIGURE 1.1

Four alternatives were then considered for providing 100-year flood protection. These alternatives included:

Alternative 1; a nonstructural alternative emphasizing right-of-way purchases and regulatory measures as opposed to reliance on capital improvements.

Alternative 2; emphasizing improvement of the designated FEMA floodway and containing flood flows within the floodway limits.

Alternative 3; emphasizing construction of underground collectors along flood paths so that permanent disruption of existing neighborhoods could be minimized.

Alternative 4; a "multi-use" alternative emphasizing joint use of floodways for flood management and recreation.

Improvements were then identified and developed based on the selection of the "multi-use" alternative. The primary feature of this plan was a three-mile long native desert parkway along Upper East Fork Cave Creek, similar in concept to the Indian Bend Wash project in Scottsdale, but using native vegetation. A complete system of major channels, box culverts, detention basins and pipelines along with their costs and relative priority were also developed for budgetary and preliminary layout purposes.

The construction cost of the recommended facilities to provide 100-year flood protection is estimated at $74,000,000. An estimated $40,000,000 is needed to fund construction of the top priority projects. These projects include a new multi-use Upper East Fork Cave Creek channel, new open channel, detention and box culvert improvements along 9th Street, and a system of box culverts under Bell Road.

CONCLUSIONS

The recommendations made in this report are based on the following conclusions:

1. The use of the two-dimensional diffusion model indicated that flow in Upper East Fork Cave Creek splits near Grovers Avenue and 21st Street. One branch follows the delineated FEMA alignment. A second branch turns south and follows 21st and 20th Streets through a series of local collector streets to the Greenway Channel.

2. Plate 2.1 summarizes runoff quantities computed using the TR-20 model for the 100-year storm.

3. Plate 4.1 shows the recommended alternative, including design flows for all conveyance and design facilities. This alternative allows for joint use of the Upper East Fork Cave Creek floodway for flood management and for recreation.

4. Implementation of the recommended alternative will result in changes in the design flows for the Greenway Channel. Design flows downstream from 12th Street have been reduced. Design flows between 12th Street and 20th Street have increased.

5. Figure 4.5 shows a comparison of the existing condition watershed outflow hydrograph and that which would be expected following implementation of the proposed master plan.

6. The recommended master plan facilities, their costs, and allowable downsizing for alternate 50-year and 10-year design frequencies are itemized on Tables 6.1 through 6.7.

OUTFLOW HYDROGRAPHS FROM DRAINAGE AREA

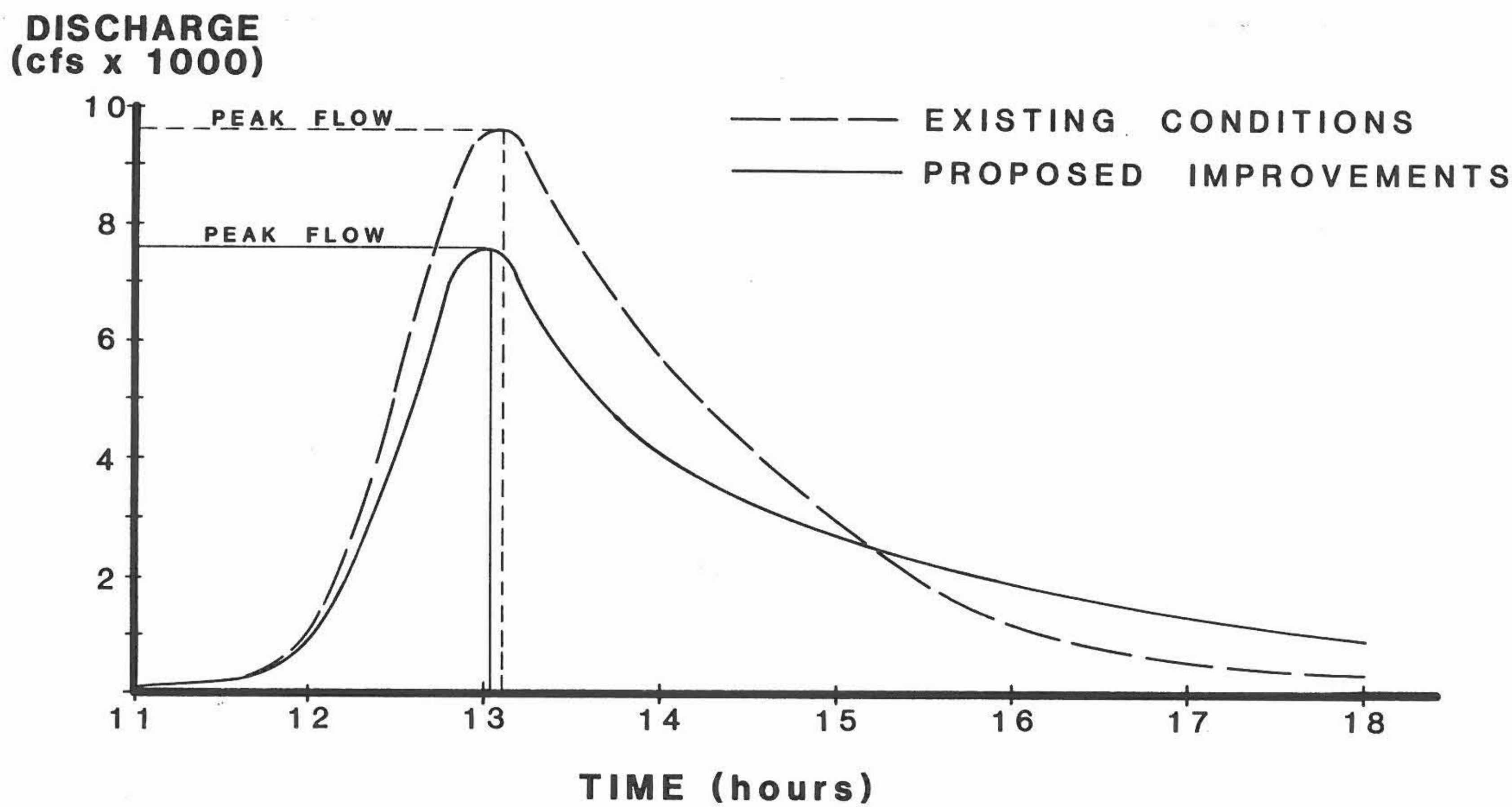

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FIGURE 4.5

TABLE 6.1

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COST COMPARISON TABLE - UNION HILLS @ CAVE CREEK

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
UNION HILLS @ CAVE CREEK ========================													
Cave Creek to Central Ave	1,250	206	Earth Apron	$60	$75,000	415	Earth Apron	$80	$100,000	518	Earth Apron	$100	$125,000
Central Ave. to 7th St.	2,650	206	11'x4' BOX	$540	$1,431,000	415	2-11'x4' BOXES	$1,080	$2,862,000	518	2-12'x4' BOXES	$1,152	$3,052,800
	5.74ac		R/W	$40,000	$229,600		R/W	$40,000	$229,600		R/W	$40,000	$229,600
TOTAL FOR U.HILLS @ CC					$1,735,600				$3,191,600				$3,407,400

COST COMPARISON TABLE - 7TH STREET

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
7TH STREET ==========													
Greenway Channel to Bell Rd.	1,020	282	72" RCP	$288	$293,760	430	84" RCP	$336	$342,720	548	90" RCP	$360	$367,200
Bell Rd. to Campo Bello Dr.	1,320	237	66" RCP	$264	$348,480	394	78" RCP	$312	$411,840	469	84" RCP	$336	$443,520
Campo Bello Dr. to Grovers Ave.	1,320	184	60" RCP	$240	$316,800	310	58"x91" Ell RCP	$292	$385,440	371	58"x91" Ell RCP	$292	$385,440
Grovers Ave. to Michigan Rd.	1,430	136	54" RCP	$216	$308,880	236	53"x83" Ell RCP	$270	$386,100	284	53"x83" Ell RCP	$270	$386,100
TOTAL FOR 7TH STREET					$974,160				$1,183,380				$1,215,060

TABLE 6.2

COST COMPARISON TABLE - 9TH STREET

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
9TH STREET ==========													
Greenway Channel to Bell Rd.	1,200	362	9'x6' BOX	$576	$691,200	701	2-8'x6' BOXES	$1,080	$1,296,000	782	2-9'x6' BOXES	$1,152	$1,382,400
	0.23ac		R/W	$40,000	$9,200		R/W	$40,000	$9,200		R/W	$40,000	$9,200
Bell Rd. to Helena Dr.	1,000	292	8'x4' BOX	$432	$432,000	531	2-7'x4' BOXES	$782	$782,000	610	2-8'x4' BOXES	$864	$864,000
Helena Dr. to Detention Basin #5	400	292	6'x4' BOX	$360	$144,000	531	2-6'x4' BOXES	$720	$288,000	610	2-6'x4' BOXES	$720	$288,000
Detention Basin #5	26.6ac		R/W	$40,000	$1,064,000		R/W	$40,000	$1,064,000		R/W	$40,000	$1,064,000
			Constr.		$575,000		Constr.		$1,041,000		Constr.		$1,150,000
Detention Basin #5 to Grovers Ave.	660	402	2-8'x4' BOXES	$864	$570,240	735	3-11'x4' BOXES	$1,620	$1,069,200	865	3-11'x4' BOXES	$1,620	$1,069,200
Grovers Ave. to Villa Rita Dr.	1,560	283	8'x4' BOX	$432	$673,920	527	2-7'x4' BOXES	$792	$1,235,520	619	2-8'x4' BOXES	$864	$1,347,840
Villa Rita Dr. to Detention Basin #2	400	283	5'x4' BOX	$342	$136,800	527	7'x4' BOX	$396	$158,400	619	8'x4' BOX	$432	$172,800
Detention Basin #2	10.0ac		R/W	$40,000	$400,000		R/W	$40,000	$400,000		R/W	$40,000	$400,000
			Constr.		$364,000		Constr.		$422,000		Constr.		$459,800
Detention Basin #2 to Morrow Dr.	1,000	656	Modify Ex Channel	$80	$80,000	1,131	Modify Ex Channel	$98	$98,000	1,365	Modify Ex Channel	$150	$150,000
	1.38ac		R/W	$40,000	$55,200		R/W	$40,000	$55,200		R/W	$40,000	$55,200
Morrow Dr. to Utopia Rd.	1,650	208	Use Exist Channel	$0	$0	379	Use Exist Channel	$0	$0	463	Use Exist Channel	$0	$0
	1.14ac		R/W	$40,000	$45,600		R/W	$40,000	$45,600		R/W	$40,000	$45,600
SUBTOTAL					$5,241,160				$7,964,120				$8,458,040

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TABLE 6.3

COST COMPARISON TABLE - 9TH STREET

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
CAMPO BELLO-GROVERS AVE. LATERAL													
Detention Basin #5 to 14th St.	1,320	529	Concrete Channel	$100	$132,000	895	Concrete Channel	$110	$145,200	1,064	Concrete Channel	$120	$158,400
14th St. to Grovers Ave.	1,320	406	2-5'x4' BOXES	$648	$855,360	646	2-7'x4' BOXES	$792	$1,045,440	760	2-8'x4' BOXES	$864	$1,140,480
Grovers Ave. to 16th St.	1,320	358	8'x4' BOX	$432	$570,240	572	11'x4' BOX	$540	$712,800	671	2-7'x4' BOXES	$792	$1,045,440
	3.03ac		R/W	$40,000	$121,200		R/W	$40,000	$121,200		R/W	$40,000	$121,200
SUBTOTAL					$1,678,800				$2,024,640				$2,465,520

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
MORROW DRIVE LATERAL													
9th St. to 12th St.	1,700	341	8'x4' BOX	$432	$734,400	536	12'x4' BOX	$576	$979,200	677	2-8'x4' BOXES	$864	$1,468,800
12th St. to 16th St.	2,670	248	5'x4' BOX	$324	$865,080	407	8'x4' BOX	$432	$1,153,440	481	2-5'x4' BOX	$648	$1,730,160
	0.21ac		R/W	$40,000	$8,400		R/W	$40,000	$8,400		R/W	$40,000	$8,400
SUBTOTAL					$1,607,880				$2,141,040				$3,207,360

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
BELL ROAD LATERAL I													
9th St. to 13th St.	2,000	148	54" RCP	$216	$432,000	263	66" RCP	$264	$528,000	313	72" RCP	$288	$576,000
13th St. to 16th St.	1,870	148	54" RCP	$216	$403,920	263	66" RCP	$264	$493,680	313	66" RCP	$264	$493,680
SUBTOTAL					$835,920				$1,021,680				$1,069,680
TOTAL FOR 9TH ST.					$9,363,760				$13,151,480				$15,200,600

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TABLE 6.3 (Cont.)

COST COMPARISON TABLE - EAST FORK CAVE CREEK

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
EAST FORK CAVE CREEK ====================													
East Fork Cave Creek Multi-Use Channel			Multi-Use Channel		$24,225,309		Multi-Use Channel		$24,225,309		Multi-Use Channel		$24,225,309
BELL ROAD LATERAL II ====================													
East Fork Cave Creek to 22nd St.	1,120	342	12'x4' BOX	$576	$645,120	577	2-11'x4' BOXES	$1,080	$1,209,600	680	3-8'x4' BOXES	$1,296	$1,451,520
22nd St. to Cave Creek Rd.	1,300	322	8'x4' BOX	$432	$561,600	470	2-6'x4' BOXES	$720	$936,000	510	2-6'x4' BOXES	$720	$936,000
Cave Creek Rd. to 24th St.	1,340	231	6'x4' BOX	$360	$482,400	303	8'x4' BOX	$432	$578,880	360	2-5'x4' BOXES	$648	$868,320
24th St. to 28th St.	1,320	153	4'x4' BOX	$288	$380,160	254	6'x4' BOX	$360	$475,200	301	7'x4' BOX	$396	$522,720
SUBTOTAL					$2,069,280				$3,199,680				$3,778,560
20TH STREET LATERAL ===================													
East Fork Cave Creek to Grovers Ave.	900	85	48" RCP	$196	$176,400	141	60" RCP	$240	$216,000	167	60" RCP	$240	$561,600
Grovers Ave. to Union Hills Dr.	2,600	85	42" RCP	$174	$452,400	141	48" RCP	$196	$509,600	167	54" RCP	$216	$216,000
SUBTOTAL					$452,400				$509,600				$777,600

TABLE 6.4

TABLE 6.4 (Cont.)

COST COMPARISON TABLE - EAST FORK CAVE CREEK

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
GROVERS AVENUE LATERAL													
Detention Basin #3 to 26th St.	1,450	219	72" RCP	$288	$417,600	399	90" RCP	$360	$522,000	483	77"x121" Ell. RCP	$400	$580,000
26th St. to 29th St.	2,000	133	60" RCP	$240	$480,000	234	78" RCP	$312	$624,000	282	63"x98" Ell. RCP	$340	$680,000
SUBTOTAL					$897,600				$1,146,000				$1,260,000
UTOPIA ROAD LATERAL													
East Fork Cave Creek to 30th St.	1,920	225	6'x4' BOX	$360	$691,200	433	11'x4' BOX	$540	$1,036,800	532	12'x4' BOX	$576	$1,105,920
30th St. to 32nd St.	1,450	184	5'x4' BOX	$324	$469,800	351	8'x4' BOX	$432	$626,400	431	11'x4' BOXES	$540	$783,000
SUBTOTAL					$1,161,000				$1,663,200				$1,888,920
TOTAL FOR EAST FORK					$28,805,589				$30,743,789				$31,930,389

COST COMPARISON TABLE - EAST AREA

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
EAST AREA =========													
Detention Basin #6	20.5ac		R/W		$820,000		R/W		$1,600,000		R/W		$2,740,000
			Constr.		$475,000		Constr.		$884,000		Constr.		$942,590
Detention Basin #6 to 29th St.	1,750	673	Concrete Channel	$100	$175,000	1,144	Concrete Channel	$110	$192,500	1,374	Concrete Channel	$120	$210,000
	2.41ac		R/W		$800,000				$800,000				$800,000
29th St. to Phelps Rd.	1,700	373	12'x4' BOX	$576	$979,200	626	2-11'x4' BOXES	$1,080	$1,836,000	749	2-12'x4' BOXES	$1,152	$1,958,400
Phelps Rd. to Bell Rd.	750	373	8'x4' BOX	$432	$324,000	626	2-7'x4' BOXES	$792	$594,000	749	2-8'x4' BOXES	$864	$648,000
Bell Rd. to 32nd. St.	2,000	309	8'x4' BOX	$432	$864,000	519	12'x4' BOX	$576	$1,152,000	620	2-8'x4' BOXES	$864	$1,728,000
32nd. St. to Grovers Ave.	2,400	128	54" RCP	$216	$518,400	219	66" RCP	$264	$633,600	265	72" RCP	$288	$691,200
Grovers Ave. to Detention Basin #4	260	128	42" RCP	$174	$45,240	219	54" RCP	$216	$56,160	265	54" RCP	$216	$56,160
Detention Basin #4	13.7ac		R/W	$40,000	$548,000		R/W	$40,000	$548,000		R/W	$40,000	$548,000
			Constr.		$460,000		Constr.		$550,000		Constr.		$629,926
Detention Basin #4 to Culvert Outlet	1,550	140	Modify Ex Channel	$50	$77,500	272	Modify Ex Channel	$60	$93,000	336	Modify Ex Channel	$70	$108,500
Culvert under Union Hills Drive	770	100	7'x4' BOX	$396	$304,920	196	11'x4' BOX	$540	$415,800	243	12'x4' BOX	$576	$443,520
SUBTOTAL					$6,391,260				$9,355,060				$11,504,296

TABLE 6.5

COST COMPARISON TABLE - EAST AREA

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
PARADISE LANE LATERAL													
29th St. to 33rd St.	2,460	183	7'x4' BOX	$396	$974,160	316	11'x4' BOX	$540	$1,328,400	378	12'x4' BOX	$576	$1,416,960
SUBTOTAL					$974,160				$1,328,400				$1,416,960

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
BELL ROAD LATERAL III													
32nd St. to 36th St.	2,000	95	54" RCP	$216	$432,000	158	60" RCP	$240	$480,000	187	66" RCP	$264	$528,000
SUBTOTAL					$432,000				$480,000				$528,000

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
GOLF COURSE LATERAL													
Detention Basin to 38th St.	2,200	175	Earth Channel	$50	$110,000	364	Earth Channel	$50	$110,000	450	Earth Channel	$50	$110,000
38th St. to 39th St.	660	135	"	$40	$26,400	280	"	$40	$26,400	361	"	$40	$26,400
	5.05ac		R/W	$40,000	$202,000		R/W	$40,000	$202,000		R/W	$40,000	$202,000
SUBTOTAL					$338,400				$338,400				$338,400
TOTAL FOR EAST AREA					$8,135,820				$11,501,860				$13,787,656

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TABLE 6.5 (Cont.)

COST COMPARISON TABLE - GREENWAY CHANNEL EXT.

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
GREENWAY CHANNEL EXT.													
Detention Basin #6 to 27th St.	1,430	387	12'x4' BOX	$576	$823,680	653	2-11'x4' BOXES	$1,080	$1,544,400	771	2-12'x4' BOXES	$1,152	$1,647,360
27th St. to 29th St.	1,800	257	11'x4' BOX	$540	$972,000	428	2-11'x4'	$1,080	$1,944,000	508	2-11'x4' BOXES	$1,080	$1,944,000
TOTAL GRNWY CHNL. EXT.					$1,795,680				$3,488,400				$3,591,360

TABLE 6.6

COST COMPARISON TABLE - SOUTH AREA

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
SOUTH AREA ==========													
Greenway Channel to Waltann Lane	1,250	1,004	Modify Ex Channel	$120	$150,000	1,655	Modify Ex Channel	$120	$150,000	1,953	Modify Ex Channel	$120	$150,000
Waltann Lane to Greenway Rd.	1,220	1,004	2-8'x6' BOXES	$1,080	$1,317,600	1,655	2-10'x7' BOXES	$1,344	$1,639,680	1,953	2-10'x8' BOXES	$1,460	$1,781,200
Greenway Rd. to 21st Way	1,500	784	11'x6' BOX	$648	$972,000	1,277	2-9'x6' BOXES	$1,152	$1,728,000	1,503	2-10'x6' BOXES	$1,224	$1,836,000
21st Wy. to 21st Pl.	1,420	614	8'x6' BOX	$540	$766,800	1,000	11'x6' BOX	$648	$920,160	1,173	12'x6' BOX	$684	$971,280
	1.72ac		R/W	$40,000	$68,800		R/W	$40,000	$68,800		R/W	$40,000	$68,800
TOTAL FOR SOUTH AREA					$3,275,200				$4,506,640				$4,807,280
**** GRAND TOTAL ****					$54,379,569				$68,109,869				$74,306,945

TABLE 6.7

7. The total cost of all of the recommended facilities for a 100-year design frequency is $74,000,000.

8. Of the recommended facilities, the following projects have been identified as having the highest priority:

A new "multi-use" Upper East Fork Cave Creek Channel	($24,200,000)
9th Street Drainage System	($ 8,500,000)
Bell Road Laterals.	($ 7,100,000)

RECOMMENDATIONS

The following recommendations are made:

1. It is recommended that right-of-way acquisition for recommended detention basin locations, and for the Upper East Fork Cave Creek Channel begin immediately while land for these improvements is still available and affordable.

2. It is recommended that construction of the proposed Bell Road Laterals be incorporated in the design of roadway improvements for Bell Road.

3. It is recommended that conversations between the Flood Control District of Maricopa County and the County and City Parks Departments continue with the objective of developing a joint use concept for the Upper East Fork Cave Creek channel that is attractive to all end users.

4. It is recommended that negotiations begin with ADOT to provide for joint funding and construction of detention facilities recommended north of Beardsley Road.

5. It is recommended that capital improvement plans for drainage improvements be developed using Tables 6.1 through 6.7 as a guide.

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CHAPTER 1
INTRODUCTION

OBJECTIVE

This report on the Upper East Fork Cave Creek Area Drainage Master Study has been prepared for the Flood Control District of Maricopa County, the City of Phoenix and the Maricopa County Highway Department to achieve the following objectives:

1. To document the status of existing runoff and flooding conditions in the study area.
2. To identify and evaluate alternatives for providing 100-year flood protection throughout the study area.
3. To identify improvements needed to implement the recommended alternative.
4. To develop cost estimates and preliminary engineering design data for the proposed flood protection plan.

STUDY AREA

The study area is shown on Figure 1.1. It includes approximately 16 square miles, encompassing the watershed of the Upper East Fork Cave Creek. The area is bounded on the north by the Granite Reef Aqueduct of the Central Arizona Project. The Paradise Valley Detention Structure prevents runoff from entering the study area from the north. The east and southeast edge of the study area is the Cave Creek - Indian Bend Wash divide. The study area is bounded by Lookout Mountain to the south and by Cave Creek to the west.

UPPER EAST FORK - CAVE CREEK AREA DRAINAGE MASTER STUDY

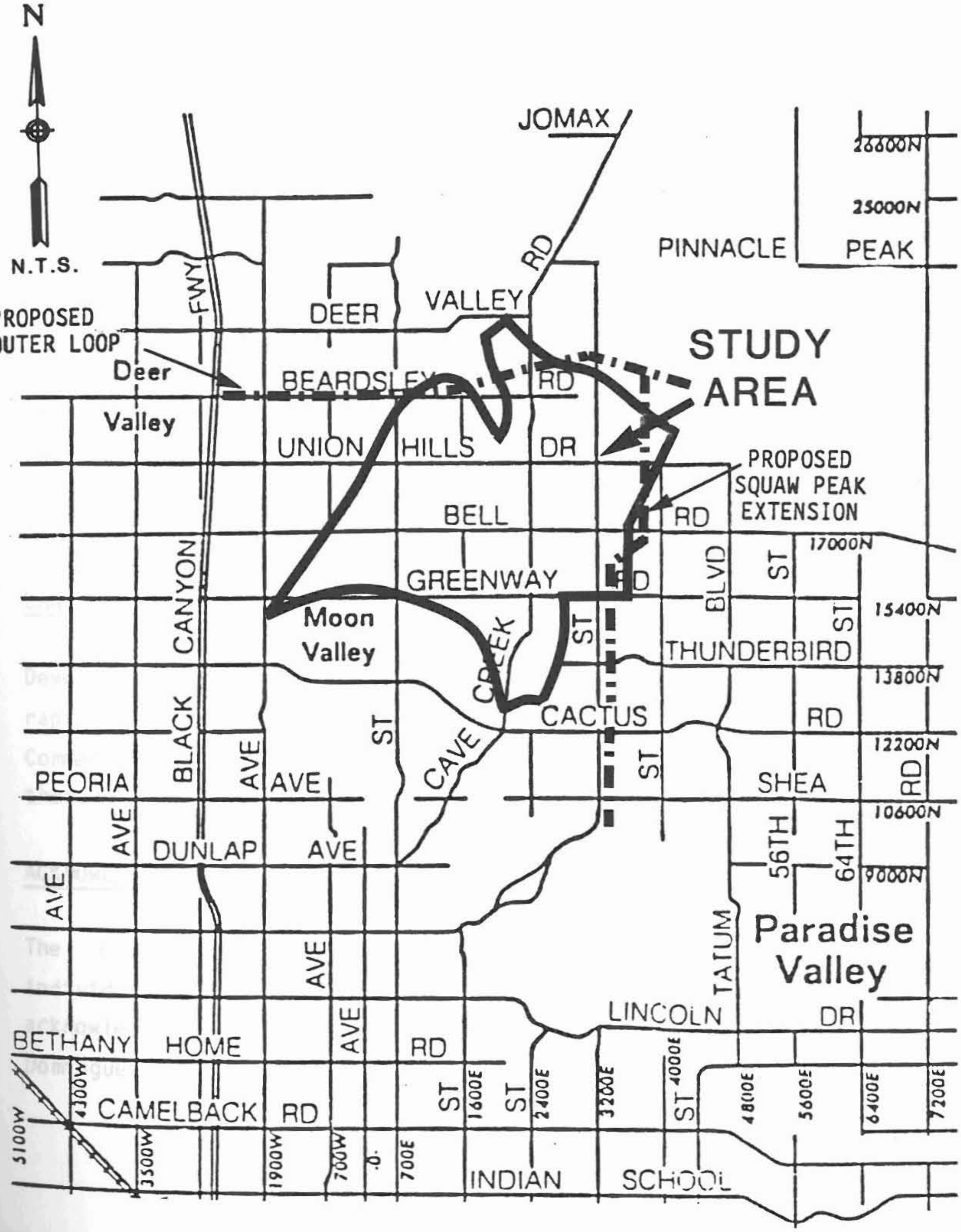


FIGURE 1.1

STUDY GUIDELINES

Under the terms of NBS/Lowry's agreement with the Flood Control District of Maricopa County, this study has been completed using the following guidelines:

1. Runoff modeling has been performed using the Soil Conservation Service TR-20 runoff synthesis model.

2. Subdrainage area boundaries have been selected to correlate with those boundaries used in the "North Central Area Master Storm Drainage Study (East Half)" completed in 1981 for the City of Phoenix.

3. Calibration and flowpath routing of the TR-20 model has been based on a 100-year flood. Runoff computations for 10-year, 50-year and 500-year floods have been extrapolated using the flowpaths identified for a 100-year flood.

LAND USE

Development within the study area is proceeding very rapidly. The majority of the area is zoned residential. Commercial development is occurring along major thoroughfares such as Bell Road and Cave Creek Road.

ACKNOWLEDGMENTS

The completion of this report was made possible by many individuals whose assistance and cooperation is gratefully acknowledged. We especially wish to thank Ms. Teresa Dominguez, Ms. Sue Mutschler, Mr. Ross Blakeley, and Mr. Tim Sutko

of the Flood Control District of Maricopa County; Mr. Dwayne Williams of the City of Phoenix, Engineering Department; and Mr. Gordon Heiniger and Mr. Dick Wallace of the Maricopa County Highway Department.

Ms. Barbara Lewis and Ms. Marty Rozelle of Dames and Moore were responsible for the public involvement coordination associated with this study.

PROJECT STAFF

The individuals that were responsible for the preparation of this report were directed by Mr. Geza E. Kmetty, P.E., R.L.S., who served as principal in charge and project manager. Mr. Kmetty was assisted by Mr. William Booth, P.E., R.L.S., chief engineer. Dr. Gary L. Guymon, PhD, P.E. served as technical advisor for this study and was responsible for developing computerized finite element modeling techniques to simulate overland flow in the study area. Mr. W. Daniel Boivin, Mr. Brian Fry, Mr. Dennis Phinney and Mr. Andrew Spear served as project staff. Graphics were prepared by Mr. Sam Maccherola.

CHAPTER 2
HYDROLOGY

METHODOLOGY

The rainfall runoff relationship for the study area was modeled using the Soil Conservation Service TR-20 computer program. TR-20 is a single rainfall event model which computes direct runoff resulting from any synthetic or natural rainstorm. It develops flood hydrographs from runoff and routes the flow through stream channels and reservoirs. It combines the routed hydrograph with those computed from tributaries and computes the peak discharges and their times of occurrence. TR-20 requires that the user specify the flood routing through the drainage area. In many cases this is fairly straightforward because the flow paths are well defined streams and washes. The Upper East Fork of Cave Creek is within an alluvial fan which is characterized by numerous small drainage features which approximate an overland flow condition, lacking well defined washes. Estimating the flood flow paths in alluvial fans can be very difficult; therefore, in areas where the routing was unclear, a two-dimensional diffusion model was applied as an aid. The diffusion model predicted flow paths were then input into the TR-20 model. The resulting TR-20 model was then felt to accurately model the probable flood routing.

TR-20 Runoff Modeling

The TR-20 computer program is based on procedures described in SCS National Engineering Handbook, Section 4. Individual subwatershed characteristics that affect runoff are described by variables that have been developed from field measurements taken in numerous watersheds throughout the country.

The East Fork Cave Creek watershed was divided into 144 subwatersheds based on existing points of concentration and homogeneity of hydrologic characteristics. The subwatersheds are shown on Plate 2.1. A mass curve of runoff is developed for each subwatershed based on the rainfall volume, rainfall distribution, and the runoff curve number (CN). CN's are determined by the user based on soil type, land use, and hydrologic condition information.

Runoff hydrographs computed for subwatersheds are combined into composite hydrographs and routed through the watershed in the natural flow sequence as specified by the user. The most recent TR-20 version replaces the convex routing method used in previous versions with a Modified Attenuated-Kinematic (Att-Kin) method which takes into account channel storage and hydrograph attenuation as the hydrograph is routed through the reach. With the Att-Kin method the discharge-flow area relationship for simple cross sections (rectangular, triangular, trapezoidal) is fit by a power curve function of the form $Q=XA^m$, where Q and A are the discharge and area at any distance and time. The coefficient X and the exponent m are specified by the user for a representative channel cross-section within the reach. Nomographs for determining X and m for a trapezoidal channel are shown on Figures 2.1 and 2.2. Alternatively, rating tables for irregular channel shapes can be input into the model. The model will then compute X and m for the section. For circular pipes, values for X and m are based on the following formulas taken from the United States Army Corps of Engineers HEC 1 Users Manual, Figure 3.6, page 25:

$$X = (0.804/n) \times S^{1/2} \times D^{1/6}$$

$$m = 5/4$$

Typical cross-sections were chosen for determining X and m for overland flow and street flow. The typical cross-sections are shown on Figure 2.3. Two cross-sections were chosen for street flow

NOMOGRAPH FOR ESTIMATING X FOR A TRAPEZOIDAL CHANNEL

$Q = XA^{M}$

SLOPE = BOTTOM SLOPE (FT/FT)
n = MANNING'S n
B = BOTTOM WIDTH (FT)

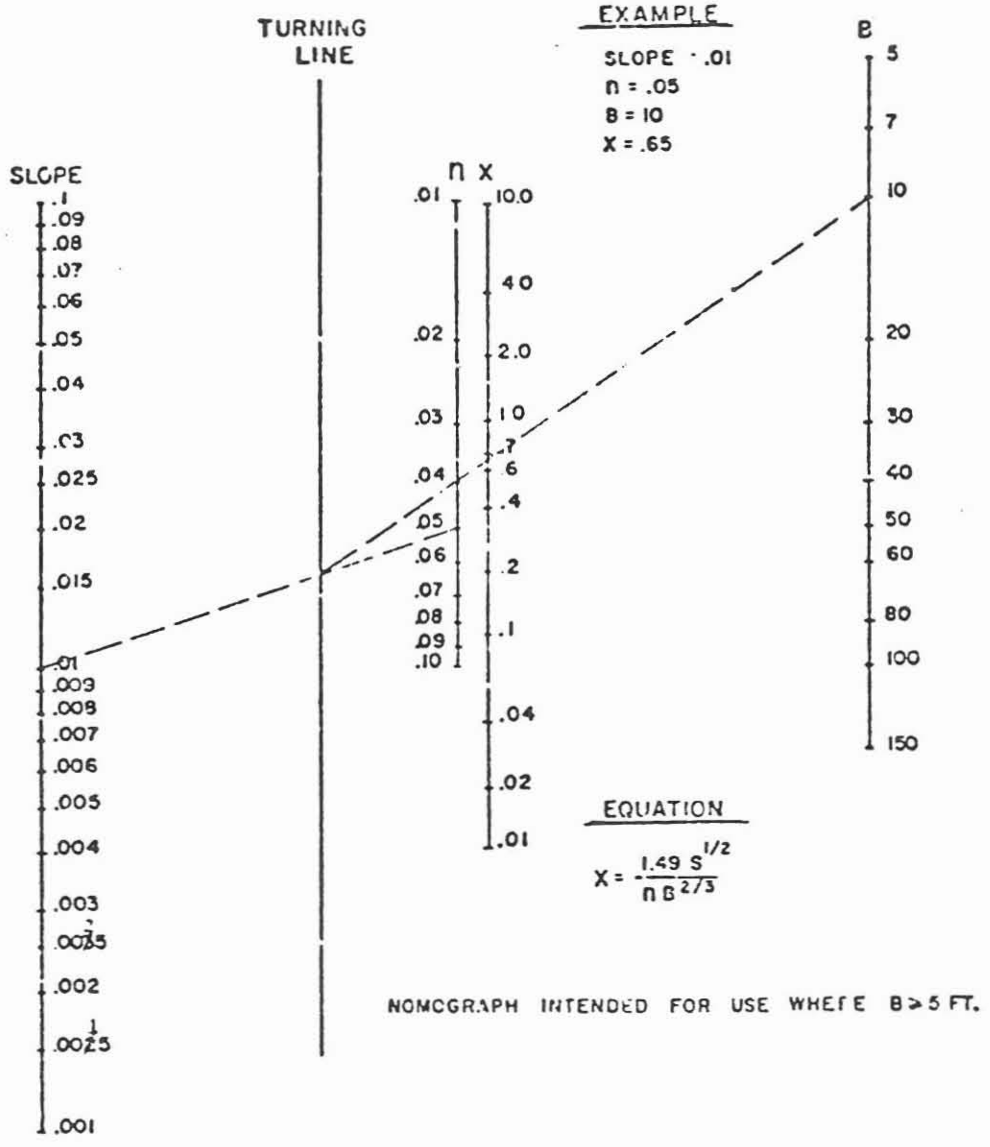
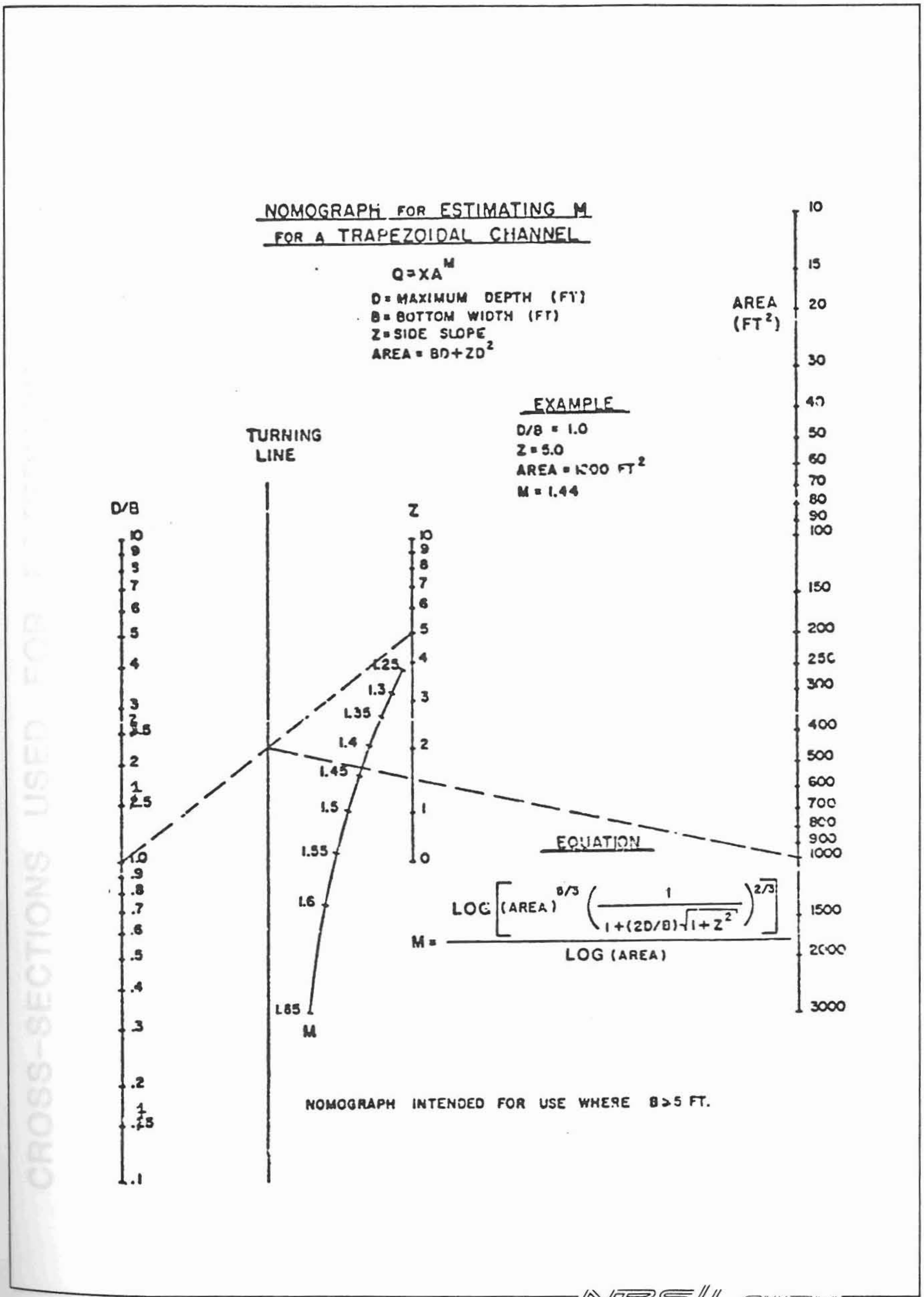


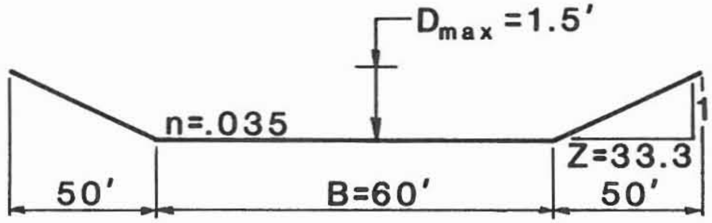
FIGURE 2.1



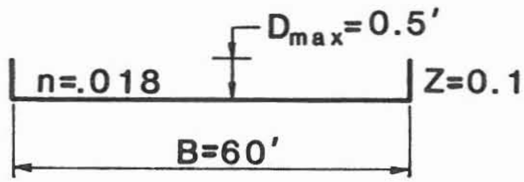
NBS/LOWRY

FIGURE 2.2

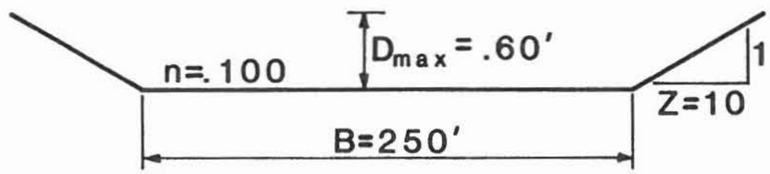
CROSS-SECTIONS USED FOR DETERMINING "X" & "m" IN THE EQUATION $Q=XA^m$ IN THE Att-Kin ROUTING PROCEDURE



STREET FLOW
(FLOW IN EXCESS OF CURB CAPACITY)



STREET FLOW
(FLOW CONTAINED WITHIN STREET)



OVERLAND FLOW
(NATURAL DESERT)

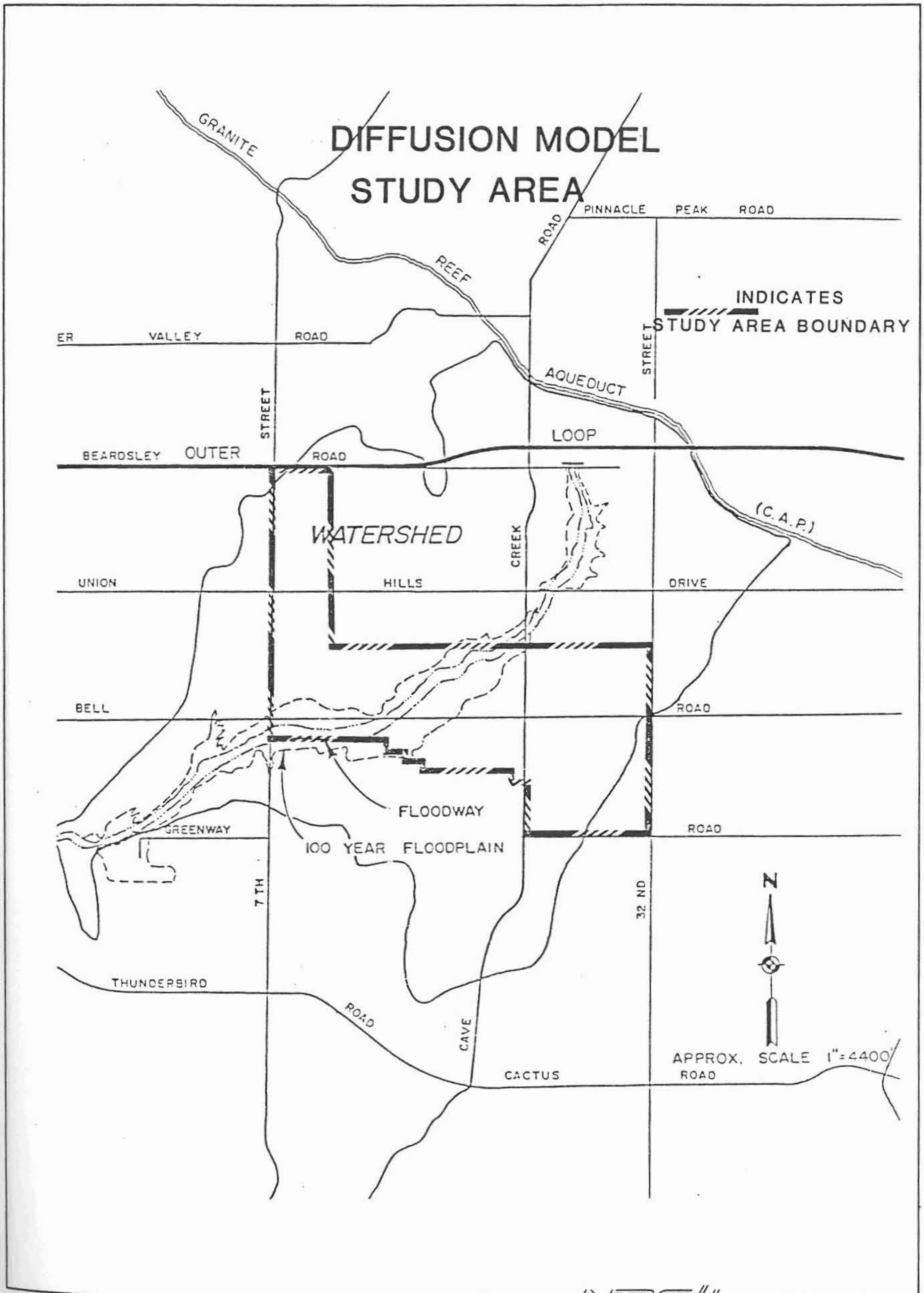
FIGURE 2.3

depending on whether the flow was contained within the street or overflowed into front yards and parking lots. A higher Manning's n was chosen for the overflow condition to take into account the additional roughness associated with trees and grass etc. in the overflow area.

Two-Dimensional Diffusion Model

The diffusion model develops hydraulic equations for two-dimensional flow for each element within a user specified grid that covers the area to be modeled. Diffusion equations are developed for each element and solved by solving a system of as many simultaneous equations as the sum of the number of grid elements and the number of grid boundaries. The solution gives the magnitude, velocity, and depth of flow across each of the four sides of each grid element. By carrying out the simulation over a number of time steps the flood is routed through each grid element. Inflow hydrographs can be specified at any element as well as critical depth outflows at any external boundary. If the external boundary of the grid is not specified as critical depth outflow it is treated as a no flow boundary, which means no flow can cross that boundary. Effective rainfall can also be modeled over the grid area by specifying an effective rainfall hyetograph. The effective rainfall is the amount of rainfall that will be in the form of runoff, the total rainfall minus losses.

The area modeled with the two-dimensional diffusion model is shown in Figure 2.4. Each grid element is 660 ft. square and is assumed to be of uniform elevation and roughness. A Manning's n of .035 was used for the study area. This value was selected after careful inspection of the area by the project team, it considers the effects of all buildings, fences and other obstructions to flow which create secondary eddies and other micro-level hydraulic phenomena in the flow field.


DIFFUSION MODEL
STUDY AREA
GRANITE
REEF
AQUEDUCT
(C.A.P.)
PINNACLE PEAK ROAD
ROAD
INDICATES
STUDY AREA BOUNDARY
ER VALLEY ROAD
STREET
BEARDSLEY OUTER ROAD
LOOP
WATERSHED
CREEK
UNION HILLS DRIVE
BELL ROAD
FLOODWAY
GREENWAY ROAD
100 YEAR FLOODPLAIN
7TH
32 ND
N
THUNDERBIRD ROAD
CAVE
CACTUS ROAD
APPROX. SCALE 1"=4400'

HYDROLOGIC CRITERIA

Rainfall Depths

Flood routing was developed for the 100-year 24-hour storm. The 10-year, 50-year, and 500-year runoff quantities were also computed based on the 100-year routing. The 24-hour rainfall depths for the return periods modeled are listed in Table 2.1. The 10-year, 50-year and 100 year depths have been used for a number of previous studies in the Cave Creek watershed. The 500-year depth has been extrapolated using Gumbel's extreme value method in accordance with guidelines adopted by the National Weather Service.

24-hour Rainfall Distribution

The 24-hour rainfall was distributed over the 24-hour period using the distribution shown in Table 2.2. This is the distribution typically used by the City of Phoenix. The City of Phoenix distribution has the shape of an S-curve that is steeper than the Type I and Type II curves normally used by the Soil Conservation Service for TR-20 modeling. This means that the City of Phoenix distribution contains a higher intensity of rainfall during the most intense period than the SCS distributions.

DRAINAGE AREA CHARACTERISTICS

The input variables required to define the subwatersheds for runoff computation are the drainage area in square miles, the curve number, and the time of concentration. These drainage area characteristics are tabulated in Table 2.3.

CITY OF PHOENIX
24-HOUR RAINFALL DEPTHS

RETURN PERIOD (YEARS)	RAINFALL DEPTH (INCHES)
10	2.53
50	3.57
100	4.04
500	5.07

24 HOUR RAINFALL DISTRIBUTION

TIME (HOUR)	ACCUMULATIVE RAINFALL	TIME (HOUR)	ACCUMULATIVE RAINFALL
0	.000	12.5	.83
.5	.004	13.0	.86
1.0	.008	13.5	.88
1.5	.013	14.0	.893
2.0	.018	14.5	.907
2.5	.022	15.0	.92
3.0	.026	15.5	.924
3.5	.031	16.0	.928
4.0	.035	16.5	.933
4.5	.040	17.0	.937
5.0	.044	17.5	.942
5.5	.048	18.0	.947
6.0	.053	18.5	.951
6.5	.057	19.0	.956
7.0	.062	19.5	.96
7.5	.066	20.0	.964
8.0	.071	20.5	.969
8.5	.075	21.0	.973
9.0	.08	21.5	.978
9.5	.093	22.0	.982
10.0	.107	22.5	.987
10.5	.12	23.0	.991
11.0	.14	23.5	.995
11.5	.17	24.0	1.00
12.0	.50		

UPPER EAST FORK - CAVE CREEK ADMS

DRAINAGE AREA NO.	AREA [SQ. MI.]	RUNOFF CURVE NO.	TIME OF CONCENT. [HRS.]
1	0.148	95	0.30
2	0.097	95	0.19
3	0.047	77	0.36
4	0.195	95	0.22
5	0.125	77	0.56
6	0.109	81	0.82
7	0.117	77	0.69
8	0.131	78	0.75
9	0.198	77	0.93
10	0.095	77	0.56
11	0.234	77	0.84
12	0.07	77	0.42
13	0.125	82	0.61
14	0.177	83	0.39
15	0.073	82	0.89
16	0.119	86	0.54
17	0.059	95	0.17
18	0.184	78	0.72
19	0.022	95	0.17
20	0.064	95	0.17
21	0.189	83	0.58
22	0.153	83	0.47
23	0.091	95	0.23
24	0.198	81	0.46
25	0.089	83	0.43
26	0.067	85	0.31
27	0.188	80	1.20
28	0.156	79	0.93
29	0.25	78	1.03
30	0.25	79	0.97
31	0.084	77	0.58
32	0.18	77	0.93
33	0.234	77	1.14
34	0.125	84	0.73
35	0.125	83	0.49
36	0.125	83	0.48
37	0.125	83	0.25
38	0.125	79	0.44
39	0.125	85	0.53
40	0.094	82	0.51
41	0.172	84	0.38
42	0.078	83	0.22
43	0.047	86	0.17
44	0.125	83	0.30
45	0.125	86	0.51
46	0.125	82	0.29
47	0.125	82	0.31

NBS/LOWRY

TABLE 2.3

UPPER EAST FORK - CAVE CREEK ADMS

DRAINAGE AREA NO.	AREA [SQ. MI.]	RUNOFF CURVE NO.	TIME OF CONCENT. [HRS.]
48	0.125	79	0.60
49	0.086	95	0.19
50	0.134	77	0.57
51	0.063	83	0.18
52	0.063	79	0.56
53	0.084	84	0.31
54	0.061	79	0.23
55	0.063	83	0.25
56	0.063	82	0.25
57	0.063	82	0.25
58	0.063	84	0.25
59	0.063	82	0.25
60	0.063	81	0.49
61	0.102	83	0.25
62	0.13	79	0.88
63	0.141	84	0.34
64	0.25	82	0.33
65	0.063	77	0.49
66	0.063	83	0.46
67	0.063	88	0.25
68	0.063	85	0.25
69	0.063	81	0.62
70	0.063	86	0.25
71	0.125	85	0.49
72	0.125	83	0.49
73	0.197	80	0.79
74	0.063	90	0.24
75	0.063	95	0.52
76	0.063	86	0.25
77	0.063	77	0.38
78	0.063	86	0.27
79	0.063	88	0.25
80	0.063	83	0.45
81	0.063	77	0.52
82	0.063	84	0.27
83	0.063	81	0.52
84	0.063	78	0.52
85	0.063	80	0.52
86	0.063	86	0.27
87	0.063	83	0.52
88	0.094	87	0.75
89	0.047	84	0.39
90	0.109	85	0.63
91	0.125	86	0.47
92	0.125	86	0.47
93	0.195	84	0.45
94	0.139	84	0.34
95	0.125	86	0.98

NBS/LOWRY

TABLE 2.3
(Cont.)

UPPER EAST FORK - CAVE CREEK ADMS

DRAINAGE AREA NO.	AREA [SQ. MI.]	RUNOFF CURVE NO.	TIME OF CONCENT. [HRS.]
96	0.125	82	0.51
97	0.188	87	0.53
98	0.094	86	0.37
99	0.094	86	0.49
100	0.078	86	0.39
101	0.047	89	0.52
102	0.063	82	0.63
103	0.081	84	0.26
104	0.069	78	0.67
105	0.063	78	0.63
106	0.063	79	0.56
107	0.059	82	0.42
108	0.025	79	0.28
109	0.063	84	0.29
110	0.073	78	0.56
111	0.07	77	0.56
112	0.061	77	0.46
113	0.053	86	0.52
114	0.128	77	1.19
115	0.094	82	0.45
116	0.094	79	0.77
117	0.313	77	2.38
118	0.231	81	1.59
119	0.231	81	1.05
120	0.231	87	0.30
121	0.25	95	0.17
122	0.355	85	0.29
123	0.213	95	0.25
124	0.219	84	0.25
125	0.117	95	0.17
126	0.158	95	0.28
127	0.159	82	0.21
128	0.036	80	0.17
129	0.108	82	0.17
13	0.031	91	0.17
131	0.119	86	0.27
132	0.145	88	0.27
133	0.08	95	0.17
134	0.197	85	0.31
135	0.042	95	0.17
136	0.066	95	0.17
137	0.078	79	0.49
138	0.203	84	0.24
139	0.188	87	0.43
140	0.125	86	0.44
141	0.188	87	0.53
142	0.25	83	1.39
TOTAL	16.46		

NBS/LOWRY

TABLE 2.3
(Cont.)

Curve Numbers

The curve number is a variable that indicates the runoff potential for a subwatershed. Its determination is based on the hydrologic soil cover complex. The soil-cover complex is a combination of the soil type and the land use and treatment classes.

All soils are divided into four basic types based on their runoff potential. Runoff potential is determined by the infiltration rate and the transmission rate. The infiltration rate is the rate at which water enters the soil at the surface and is controlled by surface conditions. The transmission rate is the rate at which the water moves in the soil and is controlled by the soil horizons. The hydrologic soil groups are A,B,C, and D. Soil group A has a low runoff potential with high infiltration rates and transmission rates. Soil group B has moderate infiltration rates and moderate transmission rates. Soil group C has slow infiltration rates and slow transmission rates. Soil group D has a high runoff potential with very slow infiltration rates and very slow transmission rates.

Soils in the East Fork of Cave Creek watershed are primarily type D soils in the higher elevations and type B in the lower alluvial floodplain areas. Soil types were determined from the "Soil Survey of Maricopa County, Arizona" developed by the United States Department of Agriculture Soil Conservation Service.

The land use and treatment classes are descriptions of the surface conditions of the subwatershed. Land use is the watershed cover and it includes every kind of vegetation, litter and mulch, and fallow as well as water surfaces and impervious surfaces such as roofs and roads. Treatment classes apply mainly to agriculture and won't be discussed here.

Curve numbers are assigned to each soil-cover complex. In areas with mixed land use such as natural land mixed with impervious surfaces such as roads and parking lots, a composite curve number is developed based on the percentage of the total area that is made up of each land use. A minimum curve number of 95 was used in areas having slopes in excess of 10%. Future condition curve numbers were developed for the watershed based on current zoning information provided by the City of Phoenix and Maricopa County. Curve numbers for each zoning classification are shown in Figure 2.5 for soil types B,C, and D. These curve numbers were developed by the City of Phoenix based on average impervious area for each zoning classification.

Where on-site detention is enforceable for future commercial and industrial developments, a curve number of 77 has been used. The low curve number allows for the regulatory intent that runoff will not be increased above preexisting conditions by these developments.

Time of Concentration

The time of concentration is the time it takes for runoff to travel from the hydraulically most distant point in a watershed to the watershed outlet. The time of concentration for each subwatershed is the sum of the overland flow time and the travel time in the street gutters.

The Upland Method was used to estimate overland flow time. The velocities used in the Upland Method were taken from Figure 2.6.

The gutter flow times were estimated using figures contained in the "City of Phoenix Storm Drain Design Manual".

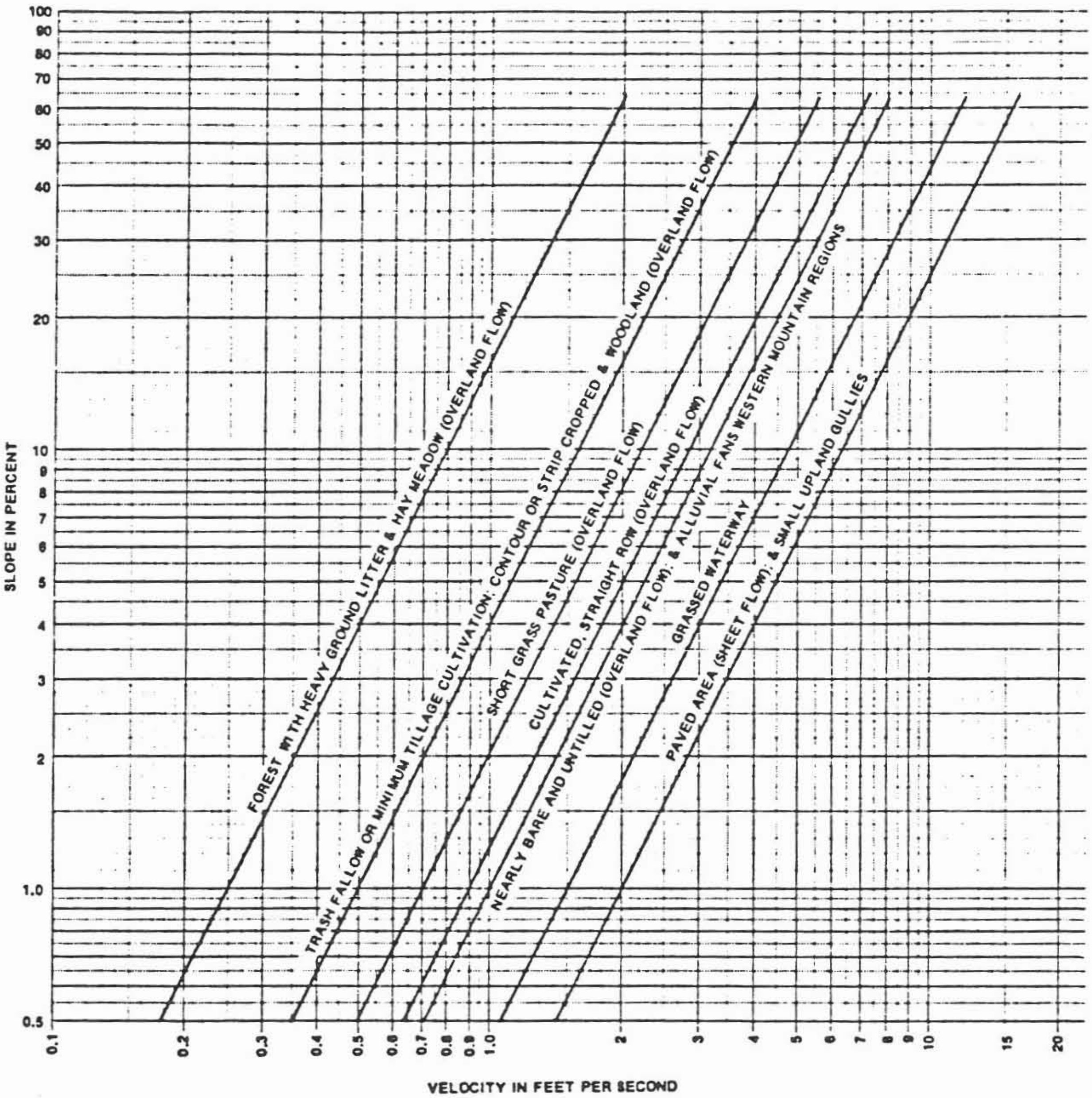
A minimum time of concentration of 10 minutes was used. At shorter times of concentration the TR-20 formula for hydrograph generation does not produce results matching actual conditions.

CURVE NUMBER SELECTION BASED ON SOIL TYPE AND ZONING

ZONING	SOIL TYPE "B"	SOIL TYPE "C"	SOIL TYPE "D"
C-0	88		
C-1	92		
C-2	92		
C-3	92		
PSC	95		
IND PK	95		
IND-1	95		
P-1	95		
PAD 6	80	88	
PAD 8	82		
PAD 10	84		
PAD 11	84		
PAD 12	84		
PAD 13	85		
PAD 14	86		
PAD R1-8	82		
R-2	84		
R-3	85		90
R-3A	90		
R-4	86		
R-4A	86		
R-5	86		
R 1-6	84		
R 1-7	83		
R 1-8	82	87	90
R 1-10	81	86	
R 1-14	80		
R 1-18	80		
R 1-35	78		
RE-35	79		87
RE-43	77		
S-1	77		86

NBS/LOWRY

FIGURE 2.5



Velocities for upland method of estimating T_c

CHAPTER 3
EXISTING CONDITIONS

INTRODUCTION

This chapter summarizes results obtained using the two-dimensional diffusion model and the TR-20 model of existing conditions. The results of the model are then compared with the results of other studies.

AREAS OF FLOODING

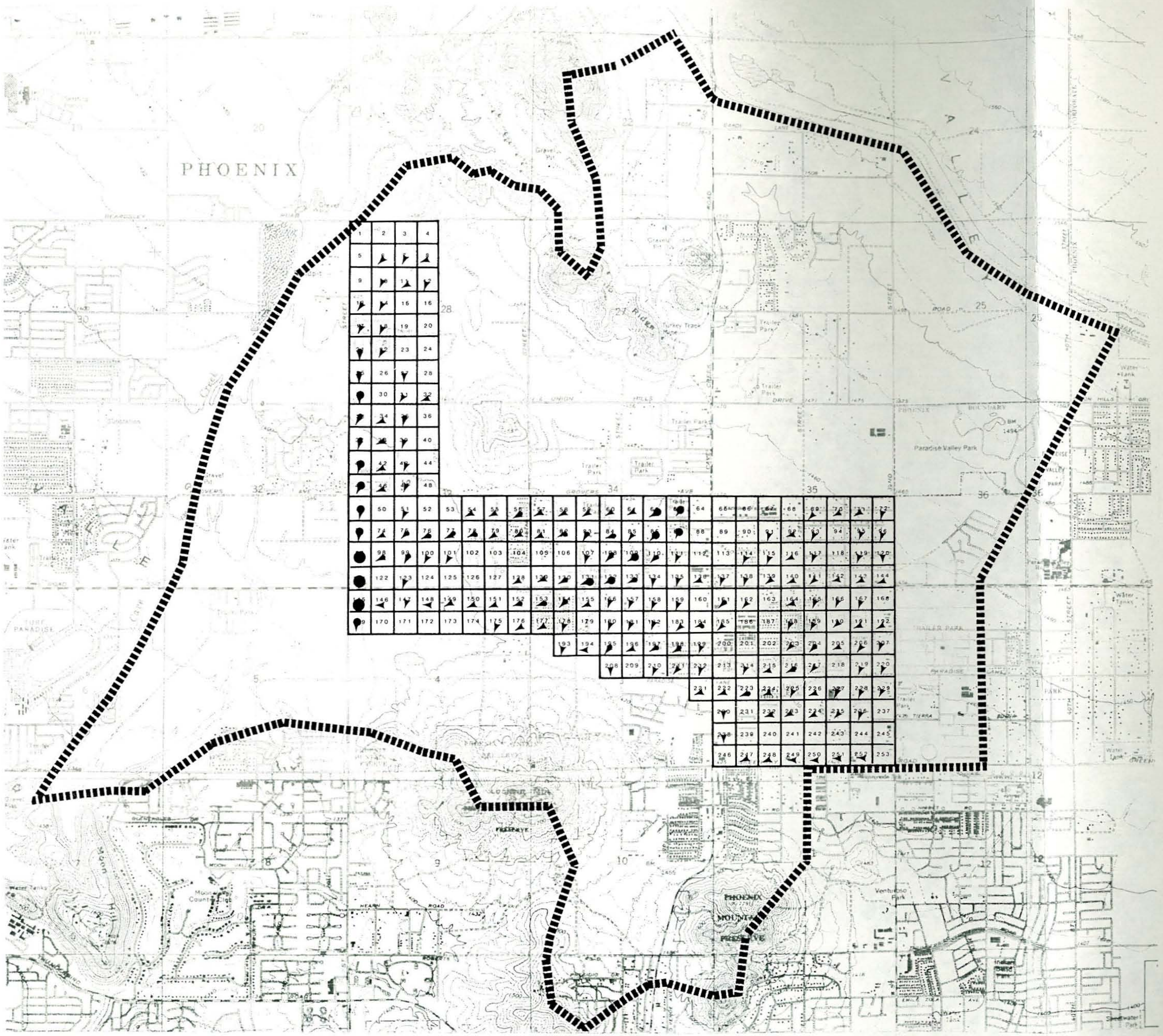
The two-dimensional diffusion model has been used to identify runoff patterns for a 100 year flood. Results are summarized on Figure 3.1.

Of particular interest is the alluvial fan pattern observed in the area along the East Fork Cave Creek south of Grover Street. Two noticeable breakout locations are observed. One breakout occurs along 21st Street to the south of the identified channel. A second divergence occurs at Bell Road near 18th Street where flow appears to split to the west and to the southwest.

Results of the diffusion model have been used to determine runoff patterns input into the TR-20 model.

RUNOFF QUANTITIES

Plate 2.1 summarizes runoff quantities computed using the TR-20 model for the 100-year storm.



LEGEND

- FLOW DIRECTION
- 68 CELL NUMBER
- CELL BOUNDARY
- CELL WITH VELOCITY*DEPTH >2
- CELL WITH VELOCITY X DEPTH >1 BUT <2
- CELL WITH VELOCITY X DEPTH >0.5 BUT <1
- STUDY BOUNDARY

RESULTS OF TWO-DIMENSION DIFFUSION MODEL

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FIGURE 3.1

COMPARISON WITH PREVIOUS STUDIES

Flows computed for the Upper East Fork of Cave Creek at the confluence of Cave Creek and the East Fork of Cave Creek compare with previous studies as follows:

Study	100-yr Runoff
Upper East Fork ADMS (This Study)	9606 cfs
FEMA Flood Insurance Study (Corp of Engineers)	9000 cfs
Greenway Road Location Study (Dibble & Associates)	9500 cfs

At other locations, larger discrepancies have occurred. These differences result from a.) differences in drainage area boundaries assigned to the various subwatersheds, b.) differences in curve numbers, and c.) differences in routing.

FEMA Flood Insurance Study

Flows assigned to the Upper East Fork of Cave Creek north of Bell Road are greater in the FEMA Study than were computed for existing conditions in this study. The difference is accounted for by the fact that subdrainage areas to the east of the Upper East Fork were assumed by FEMA to contribute to the Upper East Fork runoff. In this study, these areas have been routed through a separate subdrainage area.

Greenway Road Location Study

Flows computed in this study for existing conditions exceed design flows used in the Greenway Road Location Study in the areas east of 7th Street.

Runoff quantities compare favorably with design criteria used in the Greenway Road Location Study to the west of 7th Street.

CHAPTER 4
ALTERNATIVE ANALYSIS

INTRODUCTION

The analysis of alternative drainage plans in an alluvial fan is a complex process. When natural conditions prevail in determining the drainageways in alluvial terrain, the result is typically a complex network of braided flowpaths in which new flow networks frequently appear after major storm events. Typically, manmade flood control improvements will match the preestablished natural channels. Where channels are undefined, or vary with time or storm intensity, the identification of optimum locations for flood control improvements can prove to be very difficult.

MAJOR CHOICES IN DEVELOPING ALTERNATIVES

The complexity of master planning of drainage facilities for alluvial fan terrain may be said to result from the many choices available to the planner. A summary of major choices available are as follows:

Alignment of Conveyance Facilities

The topography of the Upper East Fork Cave Creek Watershed allows choices in whether major conveyance improvements are to run from north to south, from east to west, from northeast to southwest or in different directions in different subdrainage areas.

A constraint on alignment is that portions of the Greenway Channel, Upper East Fork Cave Creek, and other channel alignments are well defined. Where channels are well established, these channels must be incorporated into the master plan.

To minimize costs, avoidance of major development areas will also serve as a constraint limiting the options available for planning in some areas.

Interval of Conveyance Facilities

Another choice involves the interval or spacing of the major conveyance works. Conceivably, these improvements could be planned at 1/2-mile, 1-mile, 1-1/2-mile, or even 2-mile intervals. Increasing the interval increases the size requirements of improvements and visibility of facilities, but can result in a lower overall cost.

Type of Conveyance Facilities

Once alignments for conveyance facilities are identified, the type of conveyance facility must be determined. Choices available include conventional alternatives such as buried pipelines, buried box culverts, streets with inverted crowns, concrete-lined open channels, rock-lined open channels, earth-lined open channels, and grass-lined open channels. Another choice would be a joint-use alternative of recreation and flood control such as the Indian Bend Wash linear park drainageway in Scottsdale.

Reliance on Detention vs. Conveyance

Retarding the rate of flow through detention basins and drop structures will result in lower peak discharges. This allows conveyance facilities to be smaller. The degree to which detention works are incorporated into a master plan is another choice open to the planner.

A constraint on the use of detention basins in the project area is that the flood flow from the Upper East Fork Cave Creek Watershed must not be increased to prevent overloading the Arizona Canal Diversion Channel downstream. This constraint requires that detention be used to a large degree to offset increases in runoff due to development.

The use of detention will also make it possible to keep many conveyance facilities underground since smaller sized conveyance facilities will be adequate. The disadvantages of open channels in residential areas make the use of detention areas very desirable. However, detention areas need to be designed carefully or they will become eyesores.

Reliance on Nonstructural Solutions

In addition to conveyance and detention, floodplain management involving purchase of right-of-way to remove existing buildings and/or prevent construction of new facilities within the 100-year floodplain may be an alternative. In the project area, viable nonstructural solutions include relocation of mobile home parks, purchase and removal of scattered homesites, and rezoning or adding zoning stipulations on existing properties.

Acceptance of Risk

Another choice open to the planner is the degree of risk acceptable within a planning area. One can design improvements to carry any level of storm event. Generally as the acceptable return period increases, the cost of improvements also increases. At some point risk must be accepted when it becomes too expensive to further decrease it. FEMA has adopted a floodplain management criteria based upon the 100-year recurrence interval flood event. Consequently, state and local government has been forced to accept the 100-year level for designing storm drainage facilities and floodplain management plans for major flood channels. Smaller or secondary tributary channels are unaffected by the 100-year level requirement and local agencies have the option of considering other levels of protection. Nevertheless, alternatives studied herein have been sized with a 100-year level in mind.

SELECTION OF ALTERNATIVES FOR DETAILED STUDY

Using the various choices for developing a drainage plan, it would be possible to generate many reasonable alternatives for floodplain management in the Upper East Fork Cave Creek Watershed. This study focuses on four alternatives which were developed after a cursory evaluation of numerous possibilities for flood protection.

To narrow the many possible alternatives down to the four selected, several criteria were selected at the onset of the alternative evaluation process. These are as follows:

1. Alignments of conveyance facilities have been selected to optimize the use of existing drainage improvements, vacant detention sites, and open alignment corridors. Feasibility of alignment corridors has been evaluated using aerial photographs along with extensive field reconnaissance.

2. Intervals of conveyance facilities have been established at approximately 1/2 mile wherever feasible and consistent with preexisting drainageways.

3. The types of conveyance facilities have been selected to minimize visibility to the public, as well as to minimize costs over the entire lifetime of the project. Measures to accomplish this include:

   a. The use of buried pipelines to carry flows up to a maximum practical limit of approximately 500 cfs depending on available slopes. 500 cfs is the approximate capacity of a 90-inch diameter pipeline supplemented by street conveyance. For pipe sizes larger than 90-inches a box culvert is generally more economical.

   b. The use of buried box culverts to carry flows too large for economic pipeline sizes up to a maximum practical limit of approximately 1000 cfs depending on available slopes.

   c. For flows in excess of 1000 cfs, it is not considered feasible to bury conveyance facilities. Open channels are needed to carry flows this large.

4. Reliance on detention has been heavily emphasized due to concerns about future areawide development increasing flood flows above design flows of downstream channels. Any increase in the outflow hydrograph can result in overloading the Arizona Canal Diversion Channel downstream.

5. Alternatives have been sized and developed for a 100-year return period in accordance with contract requirements.

DESCRIPTION OF ALTERNATIVES

Alternatives selected for detailed evaluation are described below:

Alternative 1 - Non-Structural Alternative

This alternative emphasizes the use of right-of-way purchases and regulatory measures for area-wide floodplain management. It minimizes reliance on immediate capital expenditures and widespread capital improvements. Under this alternative, drainage would be permitted to continue to follow its existing course during storm events. Carefully planned right-of-way acquisition and zoning would be used to reduce risk within the path of expected floods.

Although this alternative is attractive from the standpoint of limiting costs in the immediate future, the issue of institutional feasibility must be assessed prior to its implementation. Historically, efforts to control or prevent construction in flood areas in the Upper East Fork watershed have not been fully successful. The feasibility of extensive property acquisition is also doubtful both for economic and institutional reasons.

Alternative - 2 Improvement of Designated FEMA Floodway

The Federal Emergency Management Agency (FEMA) has designated a floodway routing for the Upper East Fork Cave Creek shown on Figure 4.1. Under this alternative, improvements would be made along the FEMA alignment and its tributaries as shown on Figure 4.2.

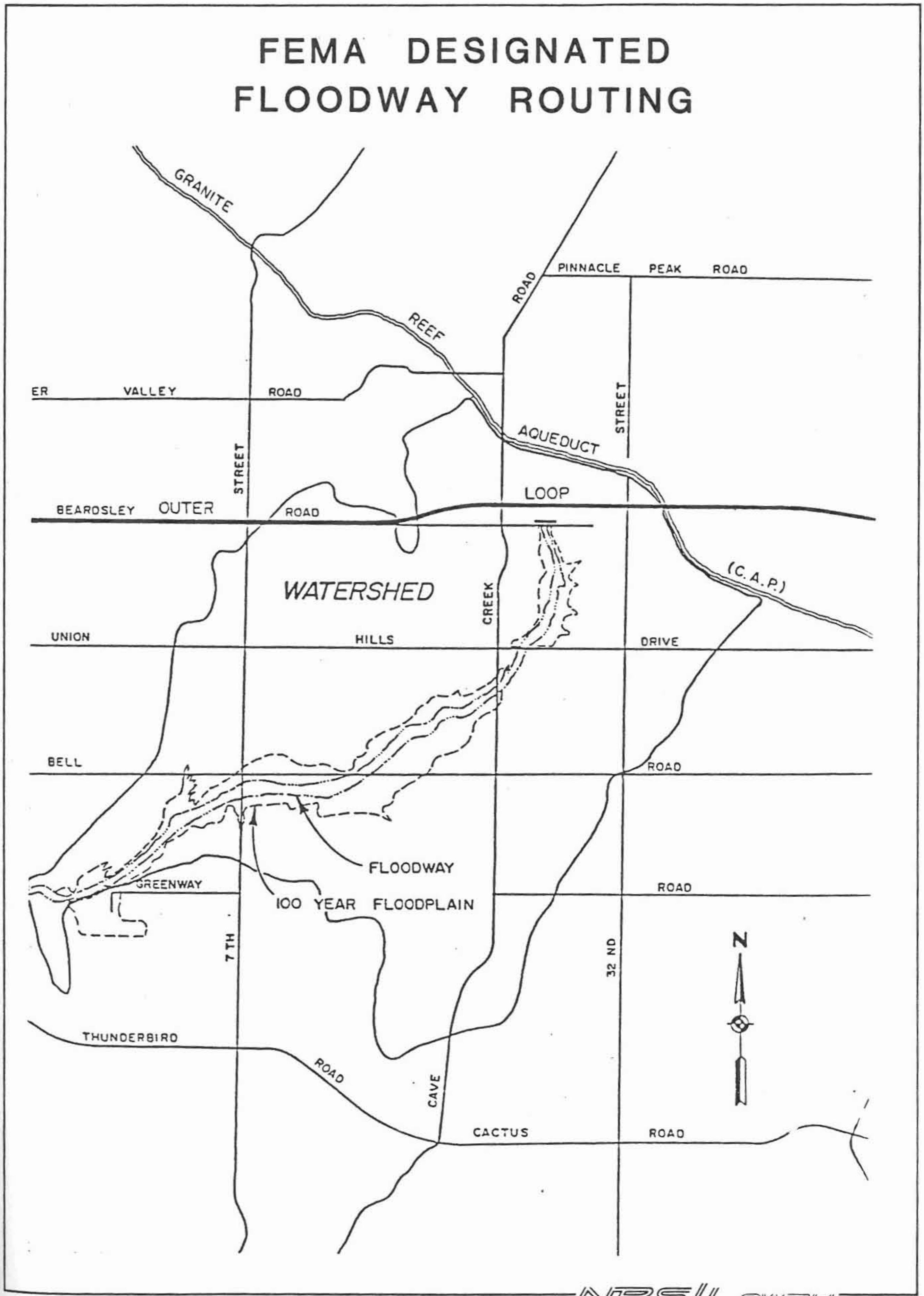

FEMA DESIGNATED
FLOODWAY ROUTING
GRANITE
REEF
AQUEDUCT
(C.A.P.)
PINNACLE PEAK ROAD
ROAD
ER VALLEY ROAD
STREET
BEARDSLEY OUTER ROAD
LOOP
WATERSHED
CREEK
UNION HILLS DRIVE
BELL ROAD
FLOODWAY
100 YEAR FLOODPLAIN
GREENWAY ROAD
7 TH
32 ND
N
THUNDERBIRD ROAD
CAVE
CACTUS ROAD
NBS/LOWRY

FIGURE 4 1

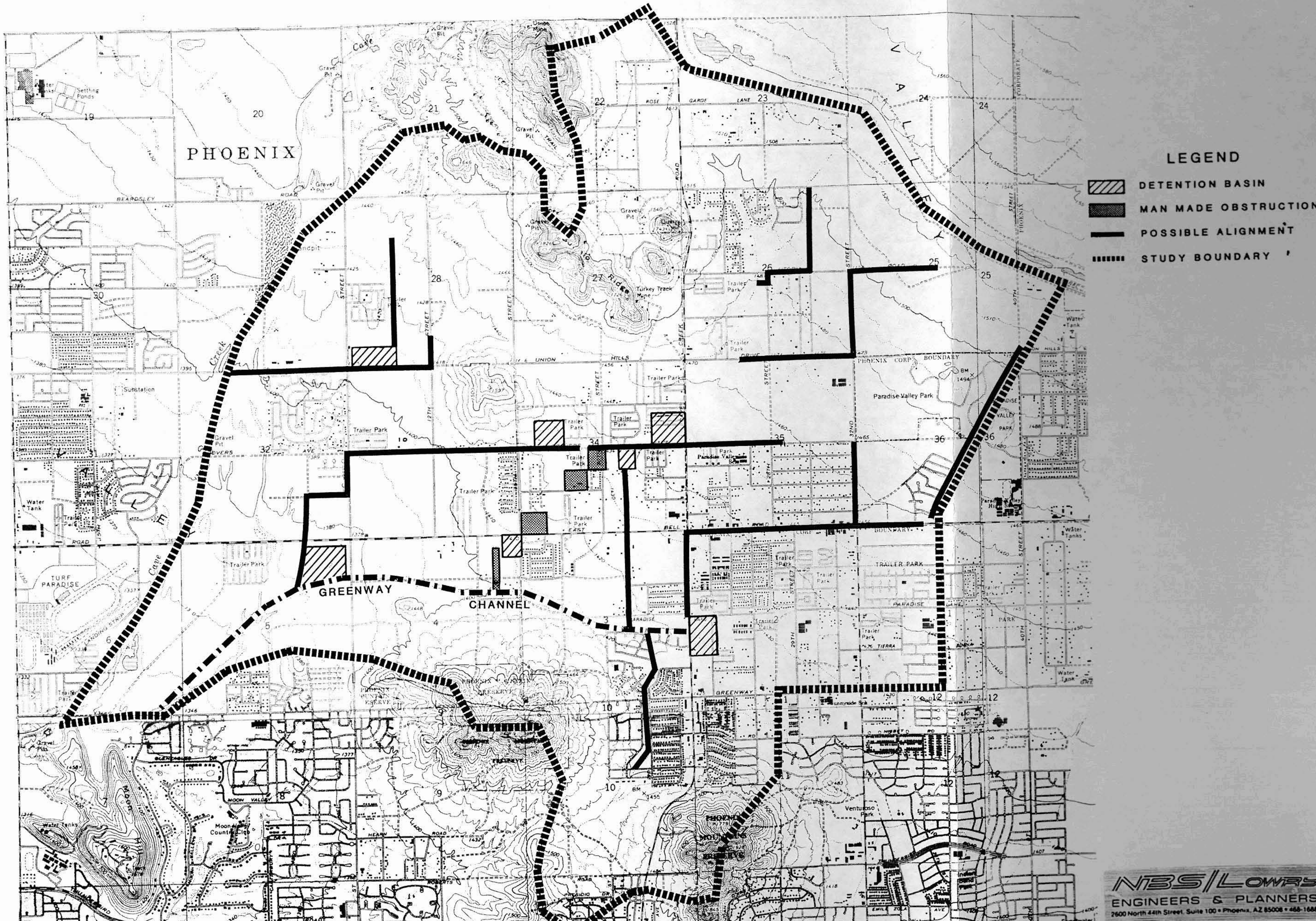
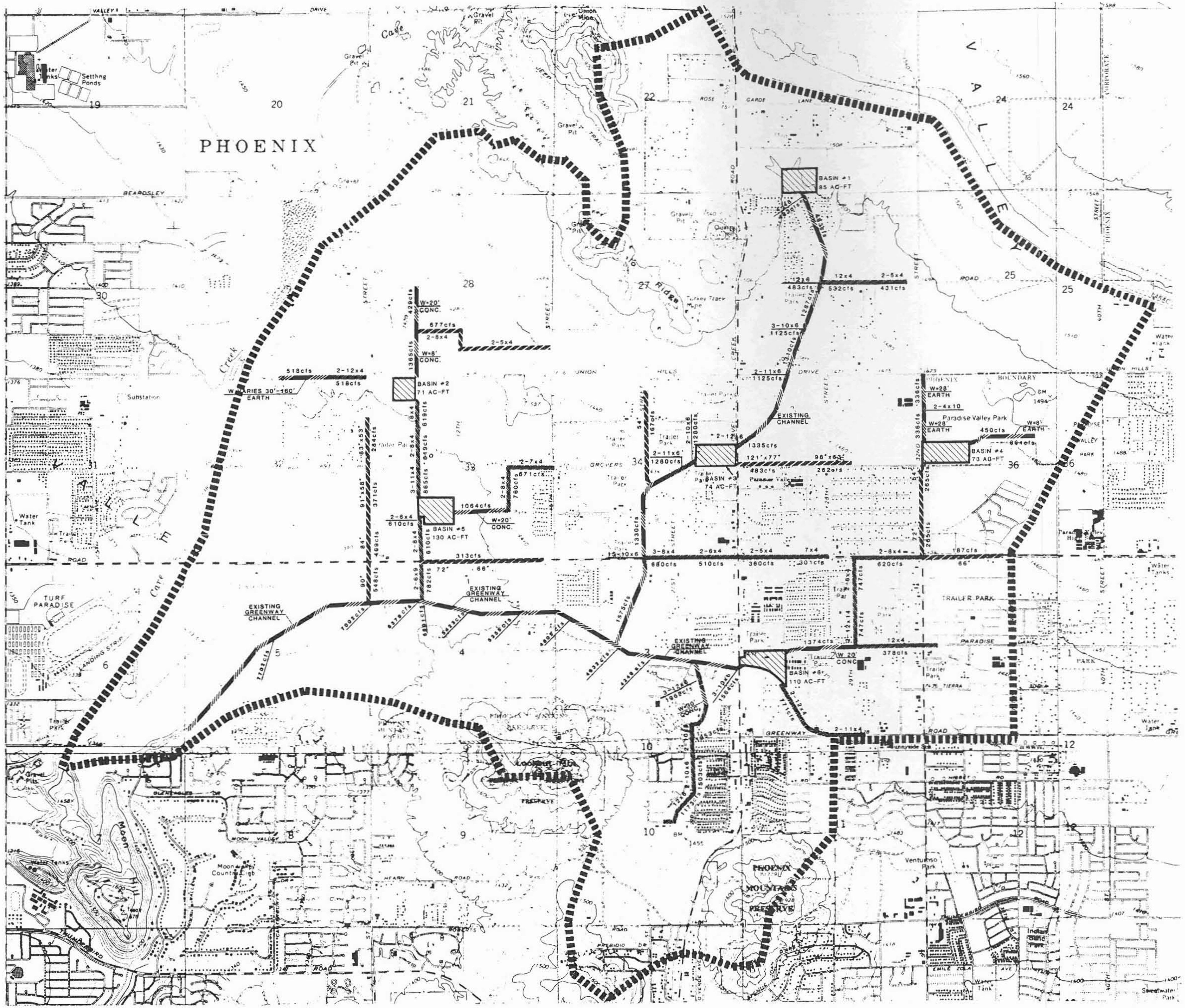


FIGURE 4.2

ALTERNATE 2



ALTERNATIVE 3 - CONVENTIONAL PLAN

FIGURE 4.3

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Alternative 4 - Multi-Use Alternative

Figure 4.4 shows the proposed alignment concepts for Alternative 4. The alignments in Alternative 4 are identical to those in Alternative 3. However these two alternatives differ in the aesthetic treatment of open channel areas.

Alternative 4 has been developed using a linear park concept. This concept would be similar to that used in the development of the Indian Bend Wash project in Scottsdale, except that greater use of native desert vegetation would be made along its alignment.

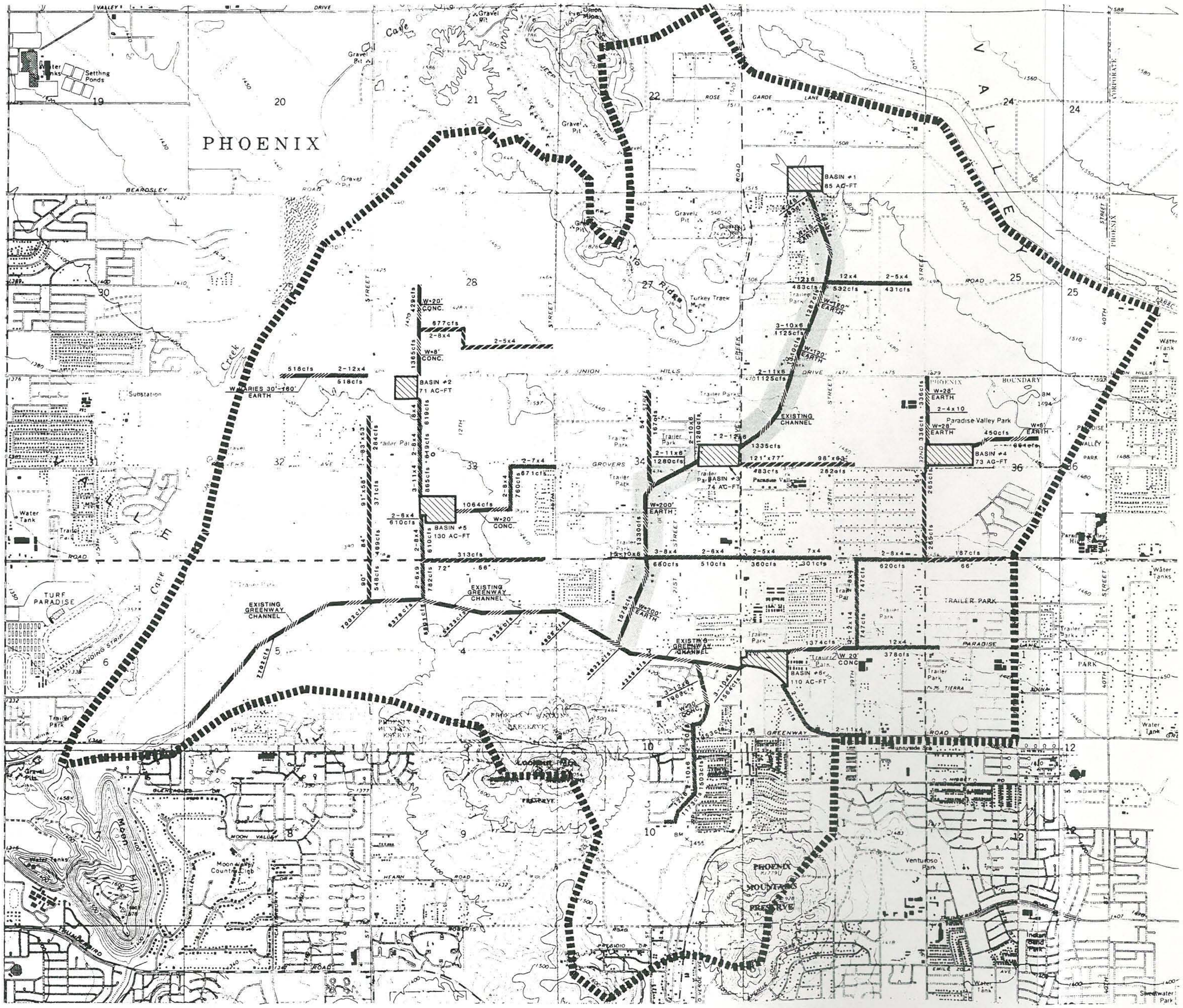
Conceivably, a system of bikepaths, nature trails, exercise courses and picnic facilities could be developed in a joint use project serving both recreation and flood control needs of the local community.

Implementation of Alternative 4 would require the cooperation of and cofunding by the Parks Department of the City of Phoenix and/or Maricopa County. In addition to costing more for initial construction, this alternative would commit the City and County Parks Departments to maintaining the dedicated park areas. While having many benefits to the public, this alternative cannot be undertaken without a commitment from the Parks Departments to undertake the project with the County Flood Control District.

EVALUATION OF ALTERNATIVES

Method of Evaluation

The evaluation of alternatives is accomplished by subjecting the numerous criteria to professional experience and judgment. To achieve a ranking of alternatives, the "Multi-Attribute



LEGEND

- MULTI-USE CHANNEL
- DETENTION BASIN
- PIPE
- BOX
- OPEN CHANNEL
- STUDY BOUNDARY

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ALTERNATIVE 4 - MULTI-USE PLAN

FIGURE 4.4

Utility Analysis" technique has been used. This technique, described in detail by Payne (see the references), has been classified as a "formalized systematic version of common sense".

Briefly, the Multi-Attribute Utility Analysis technique involves first establishing evaluation criteria and their relative weights. Then a score is assigned for each criteria for each alternative. Alternatives are then ranked based on scores assigned by the judges for each evaluation criteria.

Subjective evaluations were made using the "Delphi" method (see references). Evaluators secretly assigned scores to each criteria for each alternative, and were then given an opportunity to privately revise their scores after seeing the judgments of the other evaluators. This technique was used to reduce the possibility that one member of the evaluation team might exert a disproportionate influence over the other evaluators.

Evaluation Criteria

To objectively evaluate each alternative in light of its strengths and weaknesses, the following eight evaluation criteria have been used.

> **Constructibility:** A field reconnaissance was conducted for each alternative to determine and rate the difficulty of construction and its effect on adjoining neighborhoods and commercial traffic.
>
> **First Cost:** Alternatives were ranked according to their first cost.

Annual Cost: Alternatives were ranked according to their annual cost of operation, maintenance, risk premiums and other recurring annual costs.

Compatibility with Existing Structures: Alternatives were rated according to their compatibility with existing flood control structures both within the study area and downstream.

Aesthetics: Alternatives were rated according to their expected visual impact.

Safety: This category addressed any potential risk to the public due to construction, accidental injury after construction, or potential injury or drowning during flood events.

Effect on Neighborhoods: Open channels can effect neighborhoods much the same as freeways or other large public improvements. A fenced channel splits a neighborhood. Some alternatives involve relocation or removal of homes.

Institutional Feasibility: Implementation of any master plan requires cooperation among many agencies. Further, nonstructural elements of a plan must be enforceable to succeed. Alternatives were rated on the relative ease of implementing each alternative within existing institutional frameworks.

Results

The Engineer's evaluation team has rated the four alternatives giving equal weight to each of the above eight criteria. Based on this evaluation, the above alternatives were ranked as follows in decreasing order of preference.

Alternative 4 - Multi-Use Alternative
Alternative 3 - Underground Structure Alternative
Alternative 1 - Non-Structural Alternative
Alternative 2 - Improvement of Designated FEMA Floodway

Table 4.1 shows the scoring for each alternative based on the evaluation criteria. A maximum possible score of 12 was allowed for each of the above criteria.

Initially, Alternative 3, the Underground Structure Alternative, and Alternative 4, the Multi-use Alternative were ranked approximately equal. Alternative 4 became the preferred alternative after the Engineer's evaluation team received instructions to assume that the City of Phoenix and Maricopa County Parks Departments would take over such a project after construction.

Comparative costs for Alternatives 3 and 4 are presented in Tables 4.2 and 4.3.

RECOMMENDED ALTERNATIVE

Plate 4.1 shows the recommended alternative, including sizes and design flows for all conveyance and detention facilities.

Using the TR-20 watershed model, hydrographs have been developed and peak flows computed for each reach of the recommended alternative. The peak flows have then been used to size the various pipelines, box culverts and open channels that comprise this alternative.

TABLE 4.1
ENGINEER'S RANKING OF ALTERNATIVES

		ALT 1 NON STRUCTURAL	ALT 2 FEMA ALIGNMENT	ALT 3 UNDERGROUND STRUCTURE	ALT 4 MULTI-USE	MAX POSS SCORE
1	CONSTRUCTABILITY	8	4	10	7	12
2	FIRST COST	12	3	9	6	12
3	ANNUAL COST	6	8	8	6	12
4	COMPATIBILITY WITH EXISTING STRUCTURES	5	5	11	9	12
5	AESTHETICS	5	5	8	12	12
6	SAFETY	3	7.5	8.5	11	12
7	EFFECT ON NEIGHBORHOODS	6	4	7.5	10.5	12
8	INSTITUTIONAL FEASIBILITY	4	7	10	9	12
TOTAL SCORE		49	43.5	72	70.5	96
RELATIVE RANK		3	4	1	2	

ESTIMATED COST IN 1987 DOLLARS
ALTERNATIVE 3 - CONVENTIONAL ALTERNATIVE

PROJECT	QTY	UNIT COST	TOTAL
UNION HILLS DRIVE STORM DRAIN - 7TH ST TO CAVE CREEK			
2-12'x4' BOX CULVERTS	2650 LF	$1,152	$3,052,800
EARTH APRON	1250 LF	$100	$125,000
PROPERTY AQUISITION R/W	5.74 AC	$40,000	$229,600
SUBTOTAL			$3,407,400
GREENWAY CHANNEL - CAVE CREEK TO CAVE CREEK RD			
EARTH LINED CHANNEL	LF		COST NOT INCLUDED
7TH STREET STORM DRAIN - GREENWAY CHANNEL TO MICHIGAN AV			
90-INCH PIPE	1020 LF	$360	$367,200
84-INCH PIPE	1320 LF	$336	$443,520
58"x91" ELL. PIPE	1320 LF	$292	$385,440
53"x83" ELL. PIPE	1430 LF	$270	$386,100
SUBTOTAL			$1,582,260
9TH STREET STORM DRAIN - GREENWAY CHANNEL TO UTOPIA RD			
2-9'x6' BOX CULVERTS	1200 LF	$1,152	$1,382,400
2-8'x4' BOX CULVERTS	1000 LF	$864	$864,000
2-6'x4' BOX CULVERTS	400 LF	$720	$288,000
PROPERTY AQUISITION R/W	0.23 AC	$40,000	$9,200
CAMPO BELLO DETN. BASIN #5	26.6 AC		
PROPERTY ACQUISITION	26.6 AC	$40,000	$1,064,000
DETENTION BASIN EXCAVATI	242105 CY	$0.75	$181,580
HAULOFF	242105 CY	$4.00	$968,420
3-11'x4' BOX CULVERTS	660 LF	$1,620	$1,069,200
2-8'x4' BOX CULVERTS	1560 LF	$864	$1,347,840
8'x4' BOX CULVERT	400 LF	$432	$172,800
UNION HILLS DETENTION BASIN	10 AC		
PROPERTY ACQUISITION	10 AC	$40,000	$400,000
DETENTION BASIN EXCAVATI	96800 CY	$0.75	$72,600
HAULOFF	96800 CY	$4.00	$387,200
CONCRETE LINED CHANNEL	1000 LF	$150	$150,000
PROPERTY AQUISITION R/W	2.52 AC	40000	$100,800
SUBTOTAL			$8,458,040
BELL ROAD LATERAL I, STORM DRAIN - 9TH ST TO 16TH ST			
72-INCH PIPE	2000 LF	$288	$576,000
66-INCH PIPE	1870 LF	$264	$493,680
SUBTOTAL			$1,069,680

TABLE 4.2

ESTIMATED COST IN 1987 DOLLARS
ALTERNATIVE 3 - CONVENTIONAL ALTERNATIVE

PROJECT	QTY	UNIT COST	TOTAL
CAMPO BELLO DRIVE CHANNEL			
CONCRETE LINED CHANNEL	1320 LF	$120	$158,400
PROPERTY AQUISITION R/W	2.12 AC	$40,000	$84,800
SUBTOTAL			$243,200
14TH ST / GROVERS AV STORM DRAIN - CAMPO BELLO DR TO 18TH ST			
2-8'x4' BOX CULVERTS	1320 LF	$864	$1,140,480
2-7'x4' BOX CULVERTS	1320 LF	$792	$1,045,440
PROPERTY AQUISITION R/W	0.91 AC	$40,000	$36,400
SUBTOTAL			$2,222,320
MORROW DRIVE STORM DRAIN - 9TH ST TO 16TH ST			
2-8'x4' BOX CULVERTS	1700 LF	$864	$1,468,800
2-5'x4' BOX CULVERTS	2670 LF	$648	$1,730,160
PROPERTY AQUISITION R/W	0.21 AC	$40,000	$8,400
SUBTOTAL			$3,207,360
EAST FORK CAVE CREEK CHANNEL GREENWAY CHANNEL TO BELL ROAD			
PROPERTY ACQUIS/UNDEVELOPED	5.0 AC	$40,000	$200,000
PRIVATE RESIDENCES	5 EA	$160,000	$800,000
CONCRETE LINED CHANNEL	2880 LF	$400	$1,152,000
SUBTOTAL			$2,152,000
EAST FORK CAVE CREEK CHANNEL BELL ROAD TO DETENTION BASIN #3			
PROPERTY ACQUIS/UNDEVELOPED	8.0 AC	$40,000	$320,000
CONCRETE LINED CHANNEL	3000 LF	$400	$1,200,000
BELL ROAD CULVERT	760 LF	$1,000	$760,000
SUBTOTAL			$2,280,000

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TABLE 4.2 (Cont.)

ESTIMATED COST IN 1987 DOLLARS
ALTERNATIVE 3 - CONVENTIONAL ALTERNATIVE

PROJECT	QTY	UNIT COST	TOTAL
20TH STREET LATERAL STORM DRAIN - GROVERS AV TO UNION HILLS DR			
54-INCH PIPE	2600 LF	$216	$561,600
60-INCH PIPE	900 LF	$240	$216,000
SUBTOTAL			$777,600
BELL ROAD LATERAL II, STORM DRAIN - 20TH ST TO 28TH ST			
3-8'x4' BOX CULVERTS	1120 LF	$1,296	$1,451,520
2-6'x4' BOX CULVERTS	1300 LF	$720	$936,000
2-5'x4' BOX CULVERTS	1340 LF	$648	$868,320
7'x4' BOX CULVERT	1320 LF	$396	$522,720
SUBTOTAL			$3,778,560
EAST FORK CAVE CREEK CHANNEL			
DETENTION BASIN #3 TO UTOPIA ROAD			
PROPERTY ACQUIS/UNDEVELOPED	4.0 AC	$40,000	$160,000
PRIVATE RESIDENCES	5 EA	$160,000	$800,000
PRIVATE RES./TRAILER PADS	20 EA	$40,000	$800,000
CONCRETE LINED CHANNEL	2850 LF	$400	$1,140,000
DETENTION BASIN #3	13.7 AC		
PROPERTY ACQUISITION	13.7 AC	$40,000	$548,000
DETENTION BASIN EXCAVATI	183920 CY	$0.75	$137,940
HAULOFF	183920 CY	$4.00	$735,680
CULVERT AT CAVE CREEK ROAD	270 LF	$1,200	$324,000
CULVERT AT UNION HILLS DR	120 LF	$3,564	$427,680
CULVERT AT SIESTA LANE	100 LF	$1,836	$183,600
SUBTOTAL			$5,256,900
GROVERS AV LATERAL STORM DRAIN - CAVE CREEK RD TO 28TH ST			
77'x121' ELL. PIPE	1450 LF	$400	$580,000
63'x98' ELL. PIPE	2000 LF	$340	$680,000
SUBTOTAL			$1,260,000
UTOPIA RD LATERAL STORM DRAIN			
12'x4' BOX CULVERT	1920 LF	$576	$1,105,920
11'x4' BOX CULVERT	1450 LF	$540	$783,000
SUBTOTAL			$1,888,920

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TABLE 4.2 (Cont.)

ESTIMATED COST IN 1987 DOLLARS
ALTERNATIVE 3 - CONVENTIONAL ALTERNATIVE

PROJECT	QTY	UNIT COST	TOTAL
UPPER EAST FORK CHANNEL			
UTOPIA ROAD TO BEARDSLEY ROAD			
PROP ACQS/BACK SIDE OF RES	25 LOTS	$20,000	$500,000
PROPERTY ACQUIS/UNDEVELOPED	2.0 AC	$40,000	$80,000
CONCRETE LINED CHANNEL	3200 LF	$400	$1,280,000
SUBTOTAL			$1,860,000
UPPER EAST FORK, DETENTION BASIN #1			
DETENTION BASIN	18.4 AC		
PROPERTY ACQUISITION	18.4 AC	$40,000	$736,000
DETENTION BASIN EXCAVATI	178112 CY	$0.75	$133,584
HAULOFF	178112 CY	$4.00	$712,448
SUBTOTAL			$1,582,032
SOUTH AREA CHANNEL AND STORM DRAIN			
MODIFY EXISTING CHANNEL	1250 LF	$120	$150,000
PROPERTY AQUISITION R/W	1.72 AC	$40,000	$68,800
2-10'x8' BOX CULVERTS	1220 LF	$1,460	$1,781,200
2-10'x6' BOX CULVERTS	1500 LF	$1,224	$1,836,000
12'x6' BOX CULVERT	1420 LF	$684	$971,280
SUBTOTAL			$4,807,280
GREENWAY CHANNEL EXTENTION, DETENTION BASIN #6 TO 29TH ST			
2-12'x4' BOX CULVERTS	1430 LF	$1,152	$1,647,360
2-11'x4' BOX CULVERTS	1800 LF	$1,080	$1,944,000
SUBTOTAL			$3,591,360
PARADISE LANE CHANNEL & DETENTION BASIN #6 - CAVE CREEK RD TO 29TH ST			
DETENTION BASIN	20.5 AC		
PROPERTY ACQUISITION	20.5 AC	$40,000	$820,000
PRIVATE RESIDENCES	12	$160,000	$1,920,000
DETENTION BASIN EXCAVATI	198440 CY	$0.75	$148,830
HAULOFF	198440 CY	$4.00	$793,760
CONCRETE LINED CHANNEL	1750 LF	$120	$210,000
PRIVATE RES./TRAILER PADS	20 EA	$40,000	$800,000
SUBTOTAL			$4,692,590

ESTIMATED COST IN 1987 DOLLARS
ALTERNATIVE 3 - CONVENTIONAL ALTERNATIVE

PROJECT	QTY	UNIT COST	TOTAL
PARADISE LANE LATERAL STORM DRAIN			
12'x4' BOX CULVERT	2460 LF	$576	$1,416,960
SUBTOTAL			$1,416,960
29TH STREET/BELL ROAD STORM DRAIN - PARADISE LN TO 36TH ST			
2-12'x4' BOX CULVERTS	1700 LF	$1,152	$1,958,400
2-8'x4' BOX CULVERTS	750 LF	$864	$648,000
2-8'x4' BOX CULVERTS	2000 LF	$864	$1,728,000
66-INCH PIPE	2000 LF	$264	$528,000
SUBTOTAL			$4,862,400
32ND ST STORM DRAIN			
72-INCH PIPE	2400 LF	$288	$691,200
54-INCH PIPE	260 LF	$216	$56,160
SUBTOTAL			$747,360
PARADISE VALLEY PARK DETENTION BASIN			
DETENTION BASIN	13.7 AC		
PROPERTY ACQUISITION	13.7 AC	$40,000	$548,000
DETENTION BASIN EXCAVATI	132616 CY	$0.75	$99,462
HAULOFF	132616 CY	$4.00	$530,464
MODIFY EXITING CHANNEL	1550 LF	$70	$108,500
12'x4' BOX CULVERT	770 LF	$576	$443,520
SUBTOTAL			$1,729,946
GOLF COURSE LATERAL - EARTH CHANNEL			
EARTH LINED CHANNEL	2200 LF	$50	$110,000
EARTH LINED CHANNEL	660 LF	$40	$26,400
PROPERTY AQUISITION R/W	5.05 AC	$40,000	$202,000
SUBTOTAL			$338,400
GRAND TOTAL			$63,212,568

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TABLE 4.2 (Cont.)

ESTIMATED COST IN 1987 DOLLARS
ALTERNATIVE 4 - MULTI-USE ALTERNATIVE

PROJECT	QTY	UNIT COST	TOTAL
UNION HILLS DRIVE STORM DRAIN - 7TH ST TO CAVE CREEK			
2-12'x4' BOX CULVERTS	2650 LF	$1,152	$3,052,800
EARTH APRON	1250 LF	$100	$125,000
PROPERTY AQUISITION R/W	5.74 AC	$40,000	$229,600
SUBTOTAL			$3,407,400
GREENWAY CHANNEL - CAVE CREEK TO CAVE CREEK RD			
EARTH LINED CHANNEL	LF	COST NOT INCLUDED	
7TH STREET STORM DRAIN - GREENWAY CHANNEL TO MICHIGAN AV			
90-INCH PIPE	1020 LF	$360	$367,200
84-INCH PIPE	1320 LF	$336	$443,520
58"x91" ELL. PIPE	1320 LF	$292	$385,440
53"x83" ELL. PIPE	1430 LF	$270	$386,100
SUBTOTAL			$1,582,260
9TH STREET STORM DRAIN - GREENWAY CHANNEL TO UTOPIA RD			
2-9'x6' BOX CULVERTS	1200 LF	$1,152	$1,382,400
2-8'x4' BOX CULVERTS	1000 LF	$864	$864,000
2-6'x4' BOX CULVERTS	400 LF	$720	$288,000
PROPERTY AQUISITION R/W	0.23 AC	$40,000	$9,200
CAMPO BELLO DETN. BASIN #5	26.6 AC		
PROPERTY ACQUISITION	26.6 AC	$40,000	$1,064,000
DETENTION BASIN EXCAVATI	242105 CY	$0.75	$181,580
HAULOFF	242105 CY	$4.00	$968,420
3-11'x4' BOX CULVERTS	660 LF	$1,620	$1,069,200
2-8'x4' BOX CULVERTS	1560 LF	$864	$1,347,840
8'x4' BOX CULVERT	400 LF	$432	$172,800
UNION HILLS DETENTION BASIN	10 AC		
PROPERTY ACQUISITION	10 AC	$40,000	$400,000
DETENTION BASIN EXCAVATI	96800 CY	$0.75	$72,600
HAULOFF	96800 CY	$4.00	$387,200
CONCRETE LINED CHANNEL	1000 LF	$150	$150,000
PROPERTY AQUISITION R/W	2.52 AC	40000	$100,800
SUBTOTAL			$8,458,040
BELL ROAD LATERAL I, STORM DRAIN - 9TH ST TO 16TH ST			
72-INCH PIPE	2000 LF	$288	$576,000
66-INCH PIPE	1870 LF	$264	$493,680
SUBTOTAL			$1,069,680

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TABLE 4.3

ESTIMATED COST IN 1987 DOLLARS
ALTERNATIVE 4 - MULTI-USE ALTERNATIVE

PROJECT	QTY	UNIT COST	TOTAL
CAMPO BELLO DRIVE CHANNEL			
CONCRETE LINED CHANNEL	1320 LF	$120	$158,400
PROPERTY AQUISITION R/W	2.12 AC	$40,000	$84,800
SUBTOTAL			$243,200
14TH ST / GROVERS AV STORM DRAIN - CAMPO BELLO DR TO 18TH ST			
2-8'x4' BOX CULVERTS	1320 LF	$864	$1,140,480
2-7'x4' BOX CULVERTS	1320 LF	$792	$1,045,440
PROPERTY AQUISITION R/W	0.91 AC	$40,000	$36,400
SUBTOTAL			$2,222,320
MORROW DRIVE STORM DRAIN - 9TH ST TO 16TH ST			
2-8'x4' BOX CULVERTS	1700 LF	$864	$1,468,800
2-5'x4' BOX CULVERTS	2670 LF	$648	$1,730,160
PROPERTY AQUISITION R/W	0.21 AC	$40,000	$8,400
SUBTOTAL			$3,207,360
EAST FORK CAVE CREEK MULTI-USE CHANNEL GREENWAY CHANNEL TO BELL ROAD			
PROPERTY ACQUIS/UNDEVELOPED	16.5 AC	$40,000	$660,000
PRIVATE RESIDENCES	18 EA	$160,000	$2,880,000
MASS EXCAVATION	245889 CY	$0.75	$184,417
HAULOFF	245889 CY	$4.00	$983,556
DROP STRUCTURES	7 EA	$200,000	$1,400,000
EARTH LINED CHANNEL	2880 LF	$80	$230,400
SUBTOTAL			$6,338,373
EAST FORK CAVE CREEK MULTI-USE CHANNEL BELL ROAD TO DETENTION BASIN #3			
PROPERTY ACQUIS/UNDEVELOPED	17.2 AC	$40,000	$688,000
PRIVATE RESIDENCES	5 EA	$160,000	$800,000
MASS EXCAVATION	179867 CY	$0.75	$134,900
HAULOFF	179867 CY	$4.00	$719,468
DROP STRUCTURES	6 EA	$200,000	$1,200,000
EARTH LINED CHANNEL	3000 LF	$80	$240,000
BELL ROAD CULVERT	760 LF	$1,000	$760,000
SUBTOTAL			$4,542,368

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TABLE 4.3 (Cont.)

ESTIMATED COST IN 1987 DOLLARS
ALTERNATIVE 4 - MULTI-USE ALTERNATIVE

PROJECT	QTY	UNIT COST	TOTAL
20TH STREET LATERAL STORM DRAIN - GROVERS AV TO UNION HILLS DR			
54-INCH PIPE	2600 LF	$216	$561,600
60-INCH PIPE	900 LF	$240	$216,000
SUBTOTAL			$777,600
BELL ROAD LATERAL II, STORM DRAIN - 20TH ST TO 28TH ST			
3-8'x4' BOX CULVERTS	1120 LF	$1,296	$1,451,520
2-6'x4' BOX CULVERTS	1300 LF	$720	$936,000
2-5'x4' BOX CULVERTS	1340 LF	$648	$868,320
7'x4' BOX CULVERT	1320 LF	$396	$522,720
SUBTOTAL			$3,778,560
EAST FORK CAVE CREEK MULTI-USE CHANNEL DETENTION BASIN #3 TO UTOPIA ROAD			
PROPERTY ACQUIS/UNDEVELOPED	5.0 AC	$40,000	$200,000
PRIVATE RESIDENCES	10 EA	$160,000	$1,600,000
PRIVATE RES./TRAILER PADS	60 EA	$40,000	$2,400,000
MASS EXCAVATION	160356 CY	$0.75	$120,267
HAULOFF	160356 CY	$4.00	$641,424
DROP STRUCTURES	5 EA	$200,000	$1,000,000
EARTH LINED CHANNEL	2850 LF	$100	$285,000
DETENTION BASIN #3	13.7 AC		
PROPERTY ACQUISITION	13.7 AC	$40,000	$548,000
DETENTION BASIN EXCAVATI	183920 CY	$0.75	$137,940
HAULOFF	183920 CY	$4.00	$735,680
CULVERT AT CAVE CREEK ROAD	270 LF	$1,200	$324,000
CULVERT AT UNION HILLS DR	120 LF	$3,564	$427,680
CULVERT AT SIESTA LANE	100 LF	$1,836	$183,600
SUBTOTAL			$8,603,591
GROVERS AV LATERAL STORM DRAIN - CAVE CREEK RD TO 28TH ST			
77'x121' ELL. PIPE	1450 LF	$400	$580,000
63'x98' ELL. PIPE	2000 LF	$340	$680,000
SUBTOTAL			$1,260,000
UTOPIA RD LATERAL STORM DRAIN			
12'x4' BOX CULVERT	1920 LF	$576	$1,105,920
11'x4' BOX CULVERT	1450 LF	$540	$783,000
SUBTOTAL			$1,888,920

NBS/LOWRY

TABLE 4.3 (Cont.)

ESTIMATED COST IN 1987 DOLLARS
ALTERNATIVE 4 - MULTI-USE ALTERNATIVE

PROJECT	QTY	UNIT COST	TOTAL
UPPER EAST FORK MULTI-USE CHANNEL			
UTOPIA ROAD TO BEARDSLEY ROAD			
PROP ACQS/BACK SIDE OF RES	25 LOTS	$20,000	$500,000
PROPERTY ACQUIS/UNDEVELOPED	4.5 AC	$40,000	$181,818
PRIVATE RESIDENCES	5 EA	$160,000	$800,000
MASS EXCAVATION	109711 CY	$0.75	$82,283
HAULOFF	109711 CY	$4.00	$438,844
DROP STRUCTURES	9 EA	$100,000	$900,000
EARTH LINED CHANNEL	3200 LF	$80	$256,000
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SUBTOTAL			$3,158,945
UPPER EAST FORK, DETENTION BASIN #1			
DETENTION BASIN	18.4 AC		
PROPERTY ACQUISITION	18.4 AC	$40,000	$736,000
DETENTION BASIN EXCAVATI	178112 CY	$0.75	$133,584
HAULOFF	178112 CY	$4.00	$712,448
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SUBTOTAL			$1,582,032
SOUTH AREA CHANNEL AND STORM DRAIN			
MODIFY EXISTING CHANNEL	1250 LF	$120	$150,000
PROPERTY AQUISITION R/W	1.72 AC	$40,000	$68,800
2-10'x8' BOX CULVERTS	1220 LF	$1,460	$1,781,200
2-10'x6' BOX CULVERTS	1500 LF	$1,224	$1,836,000
12'x6' BOX CULVERT	1420 LF	$684	$971,280
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SUBTOTAL			$4,807,280
GREENWAY CHANNEL EXTENTION, DETENTION BASIN #6 TO 29TH ST			
2-12'x4' BOX CULVERTS	1430 LF	$1,152	$1,647,360
2-11'x4' BOX CULVERTS	1800 LF	$1,080	$1,944,000
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SUBTOTAL			$3,591,360
PARADISE LANE CHANNEL & DETENTION BASIN #6 - CAVE CREEK RD TO 29TH ST			
DETENTION BASIN	20.5 AC		
PROPERTY ACQUISITION	20.5 AC	$40,000	$820,000
PRIVATE RESIDENCES	12	$160,000	$1,920,000
DETENTION BASIN EXCAVATI	198440 CY	$0.75	$148,830
HAULOFF	198440 CY	$4.00	$793,760
CONCRETE LINED CHANNEL	1750 LF	$120	$210,000
PRIVATE RES./TRAILER PADS	20 EA	$40,000	$800,000
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SUBTOTAL			$4,692,590

TABLE 4.3 (Cont.)

ESTIMATED COST IN 1987 DOLLARS
ALTERNATIVE 4 - MULTI-USE ALTERNATIVE

PROJECT	QTY	UNIT COST	TOTAL
PARADISE LANE LATERAL STORM DRAIN			
12'x4' BOX CULVERT	2460 LF	$576	$1,416,960
SUBTOTAL			$1,416,960
29TH STREET/BELL ROAD STORM DRAIN - PARADISE LN TO 36TH ST			
2-12'x4' BOX CULVERTS	1700 LF	$1,152	$1,958,400
2-8'x4' BOX CULVERTS	750 LF	$864	$648,000
2-8'x4' BOX CULVERTS	2000 LF	$864	$1,728,000
66-INCH PIPE	2000 LF	$264	$528,000
SUBTOTAL			$4,862,400
32ND ST STORM DRAIN			
72-INCH PIPE	2400 LF	$288	$691,200
54-INCH PIPE	260 LF	$216	$56,160
SUBTOTAL			$747,360
PARADISE VALLEY PARK DETENTION BASIN			
DETENTION BASIN	13.7 AC		
PROPERTY ACQUISITION	13.7 AC	$40,000	$548,000
DETENTION BASIN EXCAVATI	132616 CY	$0.75	$99,462
HAULOFF	132616 CY	$4.00	$530,464
MODIFY EXITING CHANNEL	1550 LF	$70	$108,500
12'x4' BOX CULVERT	770 LF	$576	$443,520
SUBTOTAL			$1,729,946
GOLF COURSE LATERAL - EARTH CHANNEL			
EARTH LINED CHANNEL	2200 LF	$50	$110,000
EARTH LINED CHANNEL	660 LF	$40	$26,400
PROPERTY AQUISITION R/W	5.05 AC	$40,000	$202,000
SUBTOTAL			$338,400
GRAND TOTAL			$74,306,945

TABLE 4.3 (Cont.)

The computations used to develop the recommended alternative are included in the appendix to this report. These computations include:

- TR-20 Computations of peak design flows
- Hydraulic Grade Line computations for all closed conduits.
- HEC-2 Water Surface Profiles for all open channels.

Detailed development of the various components of the recommended Area Drainage Master Plan is addressed in Chapter 6.

IMPACT ON GREENWAY PARKWAY CHANNEL

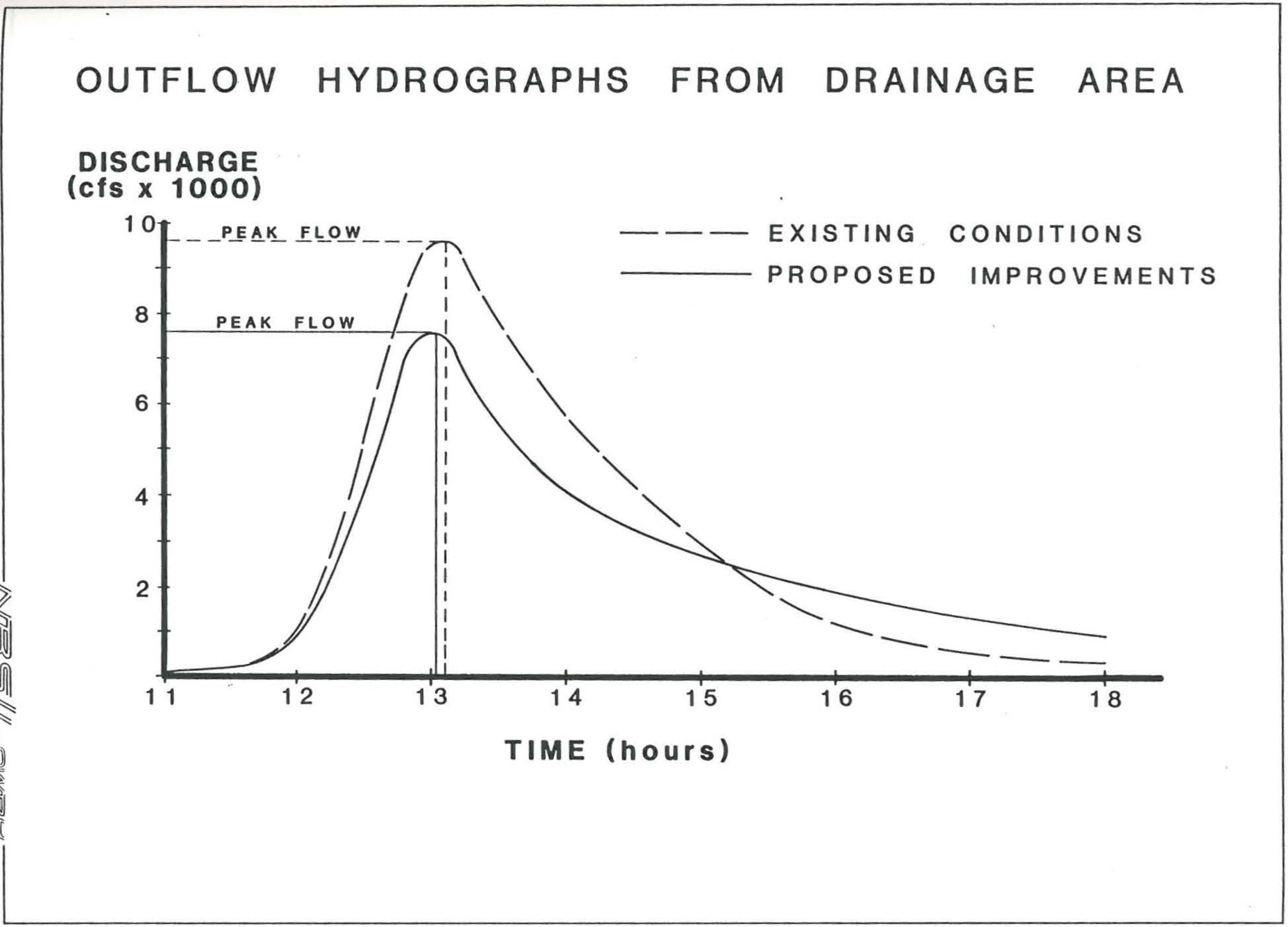
Implementation of the selected alternative will involve reevaluating the design of the Greenway Parkway Channel in light of changes in channel design flows that would result. In particular, the following should be noted:

Design flows downstream from 12th Street have been reduced due to the detention provided in the Master Plan.

Design flows between 12th Street and 20th Street have increased because the East Fork of Cave Creek would be diverted under the Master Plan and enter the channel at 20th Street rather than downstream at 12th Street.

IMPACT ON DOWNSTREAM STRUCTURES

A key consideration in the development of an Area Drainage Master Plan for the Upper East Fork Cave Creek watershed is that the projected peak watershed outflow into Cave Creek must not exceed the current peak outflow. As development proceeds, the total volume of runoff into Cave Creek will increase as the percentage of impervious surface in the study area grows. This cannot be avoided. Sufficient detention has been built into the recommended alternative to ensure that the peak runoff at buildout will be less than it is now. Figure 4.5 shows a comparison of the existing condition watershed outflow hydrograph and that which would be expected following implementation of the proposed Master Plan.


OUTFLOW HYDROGRAPHS FROM DRAINAGE AREA
DISCHARGE
(cfs x 1000)
PEAK FLOW
PEAK FLOW
EXISTING CONDITIONS
PROPOSED IMPROVEMENTS
10
8
6
4
2
11
12
13
14
15
16
17
18
TIME (hours)

CHAPTER 5
HYDRAULICS: DESIGN CRITERIA AND PROCESSES

INTRODUCTION

Described in this chapter are the general design processes and criteria used for the various phases of hydraulic analysis and design in this study.

A properly designed storm sewer system will effectively transport the storm water for the design level intended. If designed as a pressure flow system, the hydraulic grade line should not exceed any service connection where the surcharge conditions may create unacceptable flooding or structural damages. Tailwater depths at any discharge point must be considered to avoid unexpected surcharge conditions upstream. If designed as an open channel, factors such as maintenance and channel stability must be addressed as well as bank overtopping. In this design study, the following design criteria and processes have been applied to meet these conditions.

DESIGN CRITERIA

The storm drainage system, delineated in Chapter 6, will transport the runoff from a 100-year frequency storm. Tables giving the drainage system sizings for the 10, 50-, and 100-year frequency storms have also been included in Chapter 6.

1. **Layout:**

   a. Required additional right-of-way area and costs should be held to a minimum.

b. Any possible conflicts with the following utilities are considered to be critical in terms of engineering and costs.

- Water - 18" dia. or larger
- Gas - 4" dia. or larger
- Sewer - all line conflicts and some service tap obstructions

2. **Pipes or Boxes:**

a. A Manning's "n" value of .012 has been assigned for all pipes and boxes.

b. All form and manhole hydraulic losses have been neglected for this report.

c. The maximum tailwater elevations at the outfalls of the storm sewers should be equal to or less than the soffit of the outfall.

d. The hydraulic grade line of the surcharged storm sewers should remain at least 3.0 feet below the existing ground surface.

e. The soffit of each storm sewer should be at least 4.0 feet below the existing ground surface.

3. **Open Channels:**

a. Typical Manning's "n" values have been assigned as follows:

Type of Channel	Manning's "n"
Earth lined channels	
low flow channel	.030
overbank	.045
Concrete lined channels	.015

b. Maximum flow water depths of 4' were desired in channels.

c. When possible channels have been designed to flow with 2 feet of freeboard.

d. For maintenance purposes, all open channels have been designed to have a minimum bottom width of 8 feet.

e. Channel side slopes were set as follows:

Earthlined (multi-use)	=	6:1
Concrete lined	=	2:1

f. A value of 0.15 psf was used as the maximum allowable bottom sheer stress for channel tractive force analysis in earthlined channels.

4. Detention Basins:

a. A maximum detention basin depth of 6' was desired.

b. Detention basin side slopes were fixed at 6:1.

c. An orifice flow coefficient (C) of 0.61 was used for applicable storage basin outlet flow calculations.

In order to meet and implement these criteria as much as possible, certain design processes were adhered to.

DESIGN PROCESS

The design of a storm drainage system such as this is an iterative process. Hydrologic analysis of existing conditions will give estimated runoff figures for a study area. But, when a hydraulic structure is designed to channelize these flows, the hydrology calculations no longer are descriptive of the area drainage. Hence, a new set of hydrologic calculations must be made of the drainage area that are descriptive of the proposed hydraulic drainage structure. These hydrologic calculations will yield new runoff figures for the area which must then be back entered into the design of another hydraulic drainage structure. A modified structure will emerge necessitating that a new set of hydrology calculations be made. This cycle is repeated, until a hydraulic structure is converged upon.

Since the procedures and methods that make up the hydrologic modeling process are described in Chapter 2, they are not repeated here. Instead, a discussion of the various processes that were adhered to for the development of hydraulic structures follow.

1. Layout

Drainage system alignments were established by closely evaluating rights-of-way, public and private improvements, and various utility services, that exist throughout the area. Locations where critical conflicts or interferences were unavoidable have been indicated.

2. Pipes or Boxes

The most desirable slope and diameter of each pipe or box in the storm sewer system was determined using the law of conservation of energy as expressed by the Bernoulli Equation.

The element of the Bernoulli Equation expressing the head loss due to friction was determined using Manning's Equation.

$$Q = \frac{1.486}{n} (R^{2/3} \times S^{1/2} \times A)$$

in the revised form

$$S = [(Q \times n)/(1.486 \times R^{2/3} \times A)]^2$$

where: $S = \frac{h_L}{L}$, $n = 0.012$, and full pipe flow is assumed.

Using this headloss information the Hydraulic Grade Line (HGL) was plotted and checked against the existing ground surface elevation. Hydraulic Grade Line calculations have been tabulated for each section and are located in Appendix B.

3. Open Channels

a. Earthlined Channels:

Tractive Force Analysis was used to determine stable cross-sections in the earthlined channels.

For this project all such channels have been designed with an ultimate "Multi-Use" objective in mind. An important part of this objective is the resurfacing of these channels with native desert top soil and vegetation. Hence, the tractive force analysis is primarily concerned with this top soil. It is expected to have properties similar to ordinary firm loam and lay approximately 12" thick.[1] In addition, it is assumed that the soil will be placed in such a way that the channel perimeter will act cohesively and therefore offer resistance to erosion. This assumption necessarily locates the critical tractive force somewhere on the bottom of the channel and effectively eliminates the need for such considerations on the sides.[2] Further, the water is anticipated to contain colloidal silts amongst its suspended solids.

[1]See Wirth Associates Inc., A Master Plan for the CAVE CREEK WASH . . ., Chapter on "Geology and Soils', pp. 33-34, for a discussion of the soils in this area.

[2]See Morris and Wiggert, Applied Hydraulics in Engineering, Chapter 12-10 "Mechanics of Sedimentation: Stable Channels in Erodable Material', pp. 475-482, for a detailed discussion of tractive stress distribution on channel beds.

Using these assumptions and expected flow conditions a value of 0.15 was obtained from Figure 5.1 for the maximum allowable shear stress. This value is related to the channel geometry by the expression:

$$T = YRS$$

T = average bed sheer stress = 0.15 psf

Y = specific weight of water at 80°F = 62.22 pcf

S = slope of the channel and HGL = varies

R = hydraulic radius

Sufficient parameters then, can be derived from this relationship, to delineate the channel cross-section. Subsequently each reach of channel was checked for its conformance. The resulting maximum allowable velocities varied, but were generally around 3 fps.

b. Concrete Lined Channels:

For concrete lined channels care was taken to match the existing ground slope as much as possible and to eliminate the use of any drop structures. The velocities were checked for channel scour and outlet erosion properties.

Water surface profiles along all proposed open channels have been modeled using the United States Corps of Engineers HEC-2 program.

4. Detention Basins

The individual basin sizes needed for effective routing were estimated using the hydrologic data generated for this study. The

Maximum Permissible Velocities in Erodible Channels*

Channel Material	Manning Coefficient, n	Clear Water		Water Transporting Colloidal Silts	
		V (ft/sec)	τ_0 (lb/ft^2)	V (ft/sec)	τ_0 (lb/ft^2)
Fine sand, colloidal	0.020	1.50	0.027	2.50	0.075
Sandy loam, non-colloidal	0.020	1.75	0.037	2.50	0.075
Silt loam, non-colloidal	0.020	2.00	0.048	3.00	0.110
Alluvial silts, non-colloidal	0.020	2.00	0.048	3.50	0.150
Ordinary firm loam	0.020	2.50	0.075	3.50	0.15
Volcanic ash	0.020	2.50	0.075	3.50	0.15
Stiff clay, very colloidal	0.025	3.75	0.260	5.00	0.46
Alluvial silts, colloidal	0.025	3.75	0.260	5.00	0.46
Shales and hardpans	0.025	6.00	0.670	6.00	0.67
Fine gravel	0.020	2.50	0.075	5.00	0.32
Graded loam to cobbles, non-colloidal	0.030	3.75	0.380	5.00	0.66
Graded silts to cobbles, colloidal	0.030	4.00	0.430	5.50	0.80
Coarse gravel, non-colloidal	0.025	4.00	0.300	6.00	0.67
Cobbles and shingles	0.035	5.00	0.910	5.50	1.10

*Adapted from Fortier and Scobey tabulation by U.S. Reclamation Bureau.

These values apply only to well-seasoned, straight channels on mild slopes, with flow depths less than about 3 ft. For flow depths greater than 3.0 ft, increase velocity values by a factor equal to $(\frac{1}{28})(D - 3)$, up to $\frac{1}{4}$ (maximum increase) at $D = 10$ ft. For sinuous channels, decrease values by the following factors:

	Velocity	Shear Stress
Slightly sinuous	5%	10%
Moderately sinuous	13%	25%
Very sinuous	22%	40%

This table is reproduced from Morris and Wiggert, Applied Hydraulics In Engineering, Chapter 12-10, p. 477.

outflow culvert of each basin culvert was then examined. Partial pipe flow was evaluated using the Manning Equation. Surcharged pipe flow was determined by using the following Orifice Equation.

$$Q = CA\ (2gh)^{0.5}$$

Q = discharge

C = flow coefficient = 0.61

A = area of pipe opening

h = available head

g = acceleration of gravity (32.2 ft/s^2)

This information (i.e. basin size and inflow-outflow characteristics) was used to tabulate a stage, discharge and storage volume relationship for each site using the storage indication method of flood routing through reservoirs. The hydrograph of flow entering the detention basin and the stage-storage relationship were then entered into the reservoir routing routine of the Soil Conservation Services TR-20 computer program.

CHAPTER 6
PRELIMINARY PLAN

INTRODUCTION

This chapter is a companion chapter to the "Upper East Fork Cave Creek Preliminary System Layout" plans prepared for this study under separate cover. The chapter is divided into seven sections. Each section describes a different component project of the Upper East Fork Cave Creek ADMS recommended plan (Alternative 4).

The preliminary plans identify sizes and right-of-way requirements needed for a 100-year storm. Final design may differ from the preliminary design to accommodate other flood frequencies. For budgeting purposes, costs have been estimated not only for those facilities required to provide 100-year flood protection, but for 50-year and 10-year flood protection as well. Estimated costs include land purchases, materials and appurtenant work, and a 15% contingency to include any utility interferences or unforeseen costs.

Right-of-way and major utility interferences are described, as well as special engineering design considerations for each proposed project. "Major" utility interferences identified include sewer mains, and large water and gas pipelines. Telephone, cable TV, electrical, and small water and gas lines should be simple to relocate, and have been ignored.

1. UNION HILLS DRIVE - CAVE CREEK OUTLET (SHEET 7 OF 15)

The purpose of this project is to intercept flows from 7th Street north of Union Hills and divert them to Cave Creek. Table 6.1 shows the estimated cost of this project as described below for a 100-year flood, along with comparison costs for conveying 50-year and 10-year floods.

COST COMPARISON TABLE - UNION HILLS @ CAVE CREEK

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
UNION HILLS @ CAVE CREEK													
Cave Creek to Central Ave	1,250	206	Earth Apron	$60	$75,000	415	Earth Apron	$80	$100,000	518	Earth Apron	$100	$125,000
Central Ave. to 7th St.	2,650	206	11'x4' BOX	$540	$1,431,000	415	2-11'x4' BOXES	$1,080	$2,862,000	518	2-12'x4' BOXES	$1,152	$3,052,800
	5.74ac		R/W	$40,000	$229,600		R/W	$40,000	$229,600		R/W	$40,000	$229,600
TOTAL FOR U.HILLS @ CC					$1,735,600				$3,191,600				$3,407,400

TABLE 6.1

This project is unique in that most of its length lies within the floodplain of Cave Creek. It consists of 2650 lineal feet of two 12-foot X 4-foot reinforced concrete box culverts. These drain into an open channel structure that carries flow to the thalweg of Cave Creek. A box section was used here because of the limited cover conditions and to carry the large 100-year design flow. Transition to an open channel structure was made when cover was no longer possible as the flow line of the box culverts entered the Cave Creek floodplain. The proposed open channel section is compatible with neighboring development in this area.

There is no existing right-of-way on the north side of Union Hills Drive through the project alignment, except for 1320 feet immediately west of 7th Street. An estimated 35 feet of right of way will be required north of the centerline of Union Hills Drive.

A wider additional right-of-way will be needed for the open channel structure and for the concrete box transition section immediately upstream. This required right of way will taper out to a maximum width of 230 feet at the thalweg of Cave Creek.

No major utility interferences have been identified in this area.

2. 7TH STREET - GREENWAY CHANNEL OUTLET (SHEET 4 OF 15)

Table 6.2 summarizes this project and its various components, along with sizes and costs of similar facilities sized for 50-year and 10-year floods.

Starting at the Greenway Channel at the downstream outlet, and running north under 7th Street, seven feet west of centerline, this project is composed of several reaches of pipe tapering down in diameter as the alignment progresses upstream. From Greenway Channel to Bell Road, a 36 inch diameter storm drain is being

COST COMPARISON TABLE - 7TH STREET

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
7TH STREET ==========													
Greenway Channel to Bell Rd.	1,020	282	72" RCP	$288	$293,760	430	84" RCP	$336	$342,720	548	90" RCP	$360	$367,200
Bell Rd. to Campo Bello Dr.	1,320	237	66" RCP	$264	$348,480	394	78" RCP	$312	$411,840	469	84" RCP	$336	$443,520
Campo Bello Dr. to Grovers Ave.	1,320	184	60" RCP	$240	$316,800	310	58"x91" Ell RCP	$292	$385,440	371	58"x91" Ell RCP	$292	$385,440
Grovers Ave. to Michigan Rd.	1,430	136	54" RCP	$216	$308,880	236	53"x83" Ell RCP	$270	$386,100	284	53"x83" Ell RCP	$270	$386,100
TOTAL FOR 7TH STREET					$974,160				$1,183,380				$1,215,060

TABLE 6.2

constructed at the time of this writing. A 90-inch diameter pipe is required to carry the 100 year flood. The length of this 90-inch diameter is 1020 lineal feet with its soffit matching the expected high water elevation of the Greenway Channel. As a result, the pipe invert is below the channel invert at this point. Therefore a special outlet basin is proposed. This basin allows drainage in the 90" pipe flowline to discharge under head into the channel. The basin itself and any backwater that remains in the pipe after a storm is then discharged via an outlet in the bottom of the basin into a 36-inch existing low flow pipe underneath the Greenway Channel bed.

Continuing upstream the project includes 1320 lineal feet of 84-inch reinforced concrete pipe, 1320 lineal feet of 58-inch X 91-inch reinforced concrete elliptical pipe, and 1430 lineal feet of 53-inch X 83-inch reinforced concrete elliptical pipe. The total length of this pipeline is 5090 lineal feet.

Elliptical pipe was used for two reaches to attain required pipe cover while clearing over perpendicular sanitary sewers.

Right-of-way exists for 7th Street throughout this area and is adequate. No additional right-of-way is required.

Critical utility conflicts include several existing 4-inch high-pressure gas lines running under the intersection of Bell Road. These are shown on the plan and profile at an estimated depth of four feet. Also, there are several sanitary sewer lines running under the 3rd reach that will require structural and infiltration protection.

3. 9TH STREET - GREENWAY CHANNEL OUTLET (SHEET 3 OF 15)

The various projects described in this section, and their estimated costs are listed in Table 6.3. Table 6.3 also lists costs and sizes for corresponding projects sized for 50-year and 10-year storms.

Greenway Channel to Detention Basin #2. This section is made up of three reaches of drainage structure. The first consists of 1200 lineal feet of two 9-foot X 6-foot reinforced concrete boxes. The second includes 1000 lineal feet of two 8-foot X 4-foot reinforced concrete boxes. The third consists of 400 lineal feet of two 6-foot X 4-foot reinforced concrete boxes. Combined, they extend upstream from the outlet to the Greenway Channel to Detention Basin #5. A junction structure will be required for the Bell Road Lateral I where it connects from the east.

From approximately 650 feet north of Bell Road, 570 feet of an existing 8-inch ACP waterline will need to be relocated.

For an 800-foot section that starts at the Greenway Channel and goes north, an additional 25 feet of right-of-way will be required on the west side of 9th Street. Otherwise, the existing 9th Street right-of-way is sufficient.

Detention Basin #5. The basin consists of 26.6 acres of undeveloped land on the east side of 9th Street between Grovers Avenue and Bell Road. It drains into the 9th Street - Greenway Channel Outlet via two 6-foot X 4-foot reinforced concrete boxes, and receives inflow from the 9th Street channel to the north, and the Campo Bello - 14th Street - Grovers Avenue Lateral which connects at the basin's east boundary. To maintain the depth of the basin, a large cut had to be designed into its east end. At the same time, it is desired to

COST COMPARISON TABLE - 9TH STREET

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	COST TOTAL ($)
9TH STREET ==========													
Greenway Channel to Bell Rd.	1,200	362	9'x6' BOX	$576	$691,200	701	2-8'x6' BOXES	$1,080	$1,296,000	782	2-9'x6' BOXES	$1,152	$1,382,400
	0.23ac		R/W	$40,000	$9,200		R/W	$40,000	$9,200		R/W	$40,000	$9,200
Bell Rd. to Helena Dr.	1,000	292	8'x4' BOX	$432	$432,000	531	2-7'x4' BOXES	$782	$782,000	610	2-8'x4' BOXES	$864	$864,000
Helena Dr. to Detention Basin #5	400	292	6'x4' BOX	$360	$144,000	531	2-6'x4' BOXES	$720	$288,000	610	2-6'x4' BOXES	$720	$288,000
Detention Basin #5	26.6ac		R/W	$40,000	$1,064,000		R/W	$40,000	$1,064,000		R/W	$40,000	$1,064,000
			Constr.		$575,000		Constr.		$1,041,000		Constr.		$1,150,000
Detention Basin #5 to Grovers Ave.	660	402	2-8'x4' BOXES	$864	$570,240	735	3-11'x4' BOXES	$1,620	$1,069,200	865	3-11'x4' BOXES	$1,620	$1,069,200
Grovers Ave. to Villa Rita Dr.	1,560	283	8'x4' BOX	$432	$673,920	527	2-7'x4' BOXES	$792	$1,235,520	619	2-8'x4' BOXES	$864	$1,347,840
Villa Rita Dr. to Detention Basin #2	400	283	5'x4' BOX	$342	$136,800	527	7'x4' BOX	$396	$158,400	619	8'x4' BOX	$432	$172,800
Detention Basin #2	10.0ac		R/W	$40,000	$400,000		R/W	$40,000	$400,000		R/W	$40,000	$400,000
			Constr.		$364,000		Constr.		$422,000		Constr.		$459,800
Detention Basin #2 to Morrow Dr.	1,000	656	Modify Ex Channel	$80	$80,000	1,131	Modify Ex Channel	$98	$98,000	1,365	Modify Ex Channel	$150	$150,000
	1.38ac		R/W	$40,000	$55,200		R/W	$40,000	$55,200		R/W	$40,000	$55,200
Morrow Dr. to Utopia Rd.	1,650	208	Use Exist Channel	$0	$0	379	Use Exist Channel	$0	$0	463	Use Exist Channel	$0	$0
	1.14ac		R/W	$40,000	$45,600		R/W	$40,000	$45,600		R/W	$40,000	$45,600
SUBTOTAL					$5,241,160				$7,964,120				$8,458,040

TABLE 6.3

COST COMPARISON TABLE - 9TH STREET

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
CAMPO BELLO-GROVERS AVE. LATERAL													
Detention Basin #5 to 14th St.	1,320	529	Concrete Channel	$100	$132,000	895	Concrete Channel	$110	$145,200	1,064	Concrete Channel	$120	$158,400
14th St. to Grovers Ave.	1,320	406	2-5'x4' BOXES	$648	$855,360	646	2-7'x4' BOXES	$792	$1,045,440	760	2-8'x4' BOXES	$864	$1,140,480
Grovers Ave. to 16th St.	1,320	358	8'x4' BOX	$432	$570,240	572	11'x4' BOX	$540	$712,800	671	2-7'x4' BOXES	$792	$1,045,440
	3.03ac		R/W	$40,000	$121,200		R/W	$40,000	$121,200		R/W	$40,000	$121,200
SUBTOTAL					$1,678,800				$2,024,640				$2,465,520
MORROW DRIVE LATERAL													
9th St. to 12th St.	1,700	341	8'x4' BOX	$432	$734,400	536	12'x4' BOX	$576	$979,200	677	2-8'x4' BOXES	$864	$1,468,800
12th St. to 16th St.	2,670	248	5'x4' BOX	$324	$865,080	407	8'x4' BOX	$432	$1,153,440	481	2-5'x4' BOX	$648	$1,730,160
	0.21ac		R/W	$40,000	$8,400		R/W	$40,000	$8,400		R/W	$40,000	$8,400
SUBTOTAL					$1,607,880				$2,141,040				$3,207,360
BELL ROAD LATERAL I													
9th St. to 13th St.	2,000	148	54" RCP	$216	$432,000	263	66" RCP	$264	$528,000	313	72" RCP	$288	$576,000
13th St. to 16th St.	1,870	148	54" RCP	$216	$403,920	263	66" RCP	$264	$493,680	313	66" RCP	$264	$493,680
SUBTOTAL					$835,920				$1,021,680				$1,069,680
TOTAL FOR 9TH ST.					$9,363,760				$13,151,480				$15,200,600

TABLE 6.3 (Cont.)

minimize the depth of the Campo Bello Drive - 14th Street - Grovers Avenue Lateral, thereby keeping slopes and velocities, as well as required right-of-way to a minimum. To achieve these two conflicting criteria, a drop structure or equivalent design is required. Typical structures that might be considered in the final design phase are penstocks or baffles.

There are few areas of existing right-of-way in this vicinity. These small stretches, located along the borders of the basin, are dedicated to roadway usage. Therefore, rights to the use of this land for detention must be attained.

No critical utility conflicts have been identified in this area.

Detention Basin #5 to Detention Basin #2. This section is composed of three reaches, extending upstream from Detention Basin #5 to Detention Basin #2. The project runs parallel to the centerline of 9th Street at a 5-foot offset to the west. The first reach consists of 660 lineal feet of three 11-foot X 4-foot reinforced concrete boxes. The second reach includes 1560 lineal feet of two 8-foot X 4-foot reinforced concrete boxes. The third reach consists of 400 lineal feet of 8-foot X 4-foot reinforced concrete box.

There are two critical utility conflicts in this section, both involving sanitary sewer crossings. The first occurs under Grovers Avenue. While this sewer clears the top of the drainage structure it does not clear it by a safe distance. Therefore, it will require structural protection with a concrete saddle or similar device. The second sewer crosses in the location of the pipe outlet. It will need to be relocated.

There is no additional right-of-way required for this section.

Detention Basin #2. This basin requires 10.0 acres of undeveloped land and is 6 feet deep. It is located on the immediate southwest corner of Union Hills Drive and 9th Street. It drains through an 8-foot X 4-foot reinforced concrete box and receives its inlet from the north through a concrete lined open channel.

There is now no existing right-of-way in this area, except for small areas dedicated to roadway around the perimeter.

No critical utility conflicts have been identified in this area.

Detention Basin #2 to Utopia Road. Upstream from its outlet into Detention Basin #2 this project proposes a 1000-foot reach of concrete lined open channel. This channel uses the alignment of an existing earth-lined open channel, but modifies its bed. It is centered parallel to, and 30-feet west of the centerline of 9th Street. It has a typical cross-section that consists of a 20-foot bottom, a 6-foot depth, 2:1 side slopes, and an 8-foot maintenance access area on each side. A junction structure will be required to join the Morrow Drive Lateral to the east and another reach of the 9th Street - Greenway Channel to the north.

This next upstream reach consists of 1650 lineal feet of existing concrete lined open channel. It has the same alignment as the first reach. Its typical cross-section contains a 10-foot bottom, 3.5-foot depth, with 1:1 side slopes and a three foot wide access area on each side.

There is a sanitary sewer line that crosses under the channel just north of Union Hills Road. There is very little clear distance over this sewer. It will require protection against infiltration and structural damage with a concrete saddle or something similar.

Right-of-way will need to be obtained for both reaches as only easements currently exist. The first reach will require 60 feet. The second will need 30 feet.

Bell Road Lateral I. (SHEET 9 OF 15) This lateral runs upstream from the 9th Street-Greenway Channel Outlet to about 16th Street. It is made up of two reaches. The first is 2000 lineal feet of 72-inch diameter reinforced concrete pipe. The second is 1870 lineal feet of 66-inch diameter reinforced concrete pipe. The slope between these two reaches is broken to allow for clear distance under an existing sanitary sewer located at 13th Street.

Right-of-way for Bell Road throughout this area is adequate for this improvement.

Except for the sewer crossing, no critical utility interferences have been identified in this area.

Campo Bello Drive - 14th Street - Grovers Avenue Lateral. (SHEET 8 OF 15) This lateral is designed in three reaches. It drains into Detention Basin #2, through an energy dissipation drop structure. This first reach upstream from the drop structure is a concrete lined open channel that runs east for 1320 lineal feet offset 35 feet to the north of the probable future alignment of Campo Bello Drive to the outlet of the box structure that makes up the second reach. A typical cross section consists of a 20-foot bottom, 5.75-foot deep, 2:1 side slopes, and 6:1 matching shoulder grades. The shoulder areas should also be able to provide access for service.

The second reach is composed of 1320 lineal feet of two 8-foot X 4-foot reinforced concrete boxes offset 15 feet west of the probable future alignment of 14th Street.

The third reach then runs upstream and east under Grovers Avenue, 19 feet north of centerline. This reach consists of 1320 lineal feet of two 7-foot X 4-foot reinforced concrete boxes.

No critical utility conflicts have been identified for any of the reaches for this lateral.

Both of the first two reaches will need additional right-of-way. The first reach requires 70 feet of right-of-way having a south boundary coincident with the probable future centerline of Campo Bello Drive. The second reach will require 30 feet of right-of-way having an east boundary coincident with the probable future centerline of 14th Street. The existing right-of-way dedicated to Grovers Avenue will be sufficient for the third reach of drainage structure.

Morrow Drive Lateral. (SHEET 7 OF 15) This box culvert lateral drains into the 9th Street - Greenway Channel Outlet at the intersection of 9th Street and Morrow Drive. From its outlet, it proceeds upstream and east for 1350 lineal feet under Morrow Drive at an offset seven feet north of the centerline. At 12th Street the line turns south, proceeding for 350 lineal feet at an offset of 12 feet east of centerline, and then turns east for 1120 lineal feet following deepened alignment of an existing drainage channel. The proposed structure in this area will run 25 feet south of the Blue Hills - Unit 3 subdivision boundary. After 1350 lineal feet, the boxes cross under 14th Street and follow the centerline of Rosemont Drive for 1320 lineal feet to 16th Street.

The first stretch under Morrow Drive consists of two 8-foot X 4-foot reinforced concrete boxes. The 12th Street reach also consists of two 8-foot X 4-foot reinforced concrete boxes. The Rosemont Drive reach is made up of two 5-foot X 4-foot reinforced concrete boxes.

There is one critical utility conflict, a sanitary sewer under 10th Street. It will have to be relocated. Two other sanitary sewers come in close proximity to this project, and will need structural reinforcement.

There is no existing right-of-way on the east half of 12th Street. Thirty feet of right-of-way will be needed.

4. UPPER EAST FORK CAVE CREEK - GREENWAY CHANNEL OUTLET

Table 6.4 summarizes the projects identified in this section and their costs. Corresponding downsized facilities required to convey 50-year and 10-year storms are also listed in Table 6.4.

Preliminary plans for the Upper East Fork Cave Creek channel have been prepared using accepted open channel hydraulic design criteria while allowing for recreational use of the same land as envisioned under the multi-use concept. The proposed channel consists of an earth-lined open channel and several detention basins throughout its length. Continuous multi-use access is provided from its outlet at the Greenway Channel to a detention basin north of Beardsley Road. A wide, flat channel design allows considerable freedom to be extended to the landscape designers who will implement the multi-use surface features of the drainageway. To attain this, modifications to the earthlined open channel design were made.

For instance, two-foot drop structures have been used to prevent steep channel slopes from causing velocities to exceed acceptable design criteria. When two or more of these structures occur together, a 20-foot interval between them is needed to provide a maximum straight grade (slope) of 10% for bike paths, pedestrian walkways, and other recreational features unique to the multi-use concept.

COST COMPARISON TABLE - EAST FORK CAVE CREEK

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
EAST FORK CAVE CREEK ====================													
East Fork Cave Creek Multi-Use Channel			Multi-Use Channel		$24,225,309		Multi-Use Channel		$24,225,309		Multi-Use Channel		$24,225,309
BELL ROAD LATERAL II ====================													
East Fork Cave Creek to 22nd St.	1,120	342	12'x4' BOX	$576	$645,120	577	2-11'x4' BOXES	$1,080	$1,209,600	680	3-8'x4' BOXES	$1,296	$1,451,520
22nd St. to Cave Creek Rd.	1,300	322	8'x4' BOX	$432	$561,600	470	2-6'x4' BOXES	$720	$936,000	510	2-6'x4' BOXES	$720	$936,000
Cave Creek Rd. to 24th St.	1,340	231	6'x4' BOX	$360	$482,400	303	8'x4' BOX	$432	$578,880	360	2-5'x4' BOXES	$648	$868,320
24th St. to 28th St.	1,320	153	4'x4' BOX	$288	$380,160	254	6'x4' BOX	$360	$475,200	301	7'x4' BOX	$396	$522,720
SUBTOTAL					$2,069,280				$3,199,680				$3,778,560
20TH STREET LATERAL ==================													
East Fork Cave Creek to Grovers Ave.	900	85	48" RCP	$196	$176,400	141	60" RCP	$240	$216,000	167	60" RCP	$240	$561,600
Grovers Ave. to Union Hills Dr.	2,600	85	42" RCP	$174	$452,400	141	48" RCP	$196	$509,600	167	54" RCP	$216	$216,000
SUBTOTAL					$452,400				$509,600				$777,600

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TABLE 6.4

TABLE 6.4 (Cont.)

COST COMPARISON TABLE - EAST FORK CAVE CREEK

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
GROVERS AVENUE LATERAL													
Detention Basin #3 to 26th St.	1,450	219	72" RCP	$288	$417,600	399	90" RCP	$360	$522,000	483	77"x121" Ell. RCP	$400	$580,000
26th St. to 29th St.	2,000	133	60" RCP	$240	$480,000	234	78" RCP	$312	$624,000	282	63"x98" Ell. RCP	$340	$680,000
SUBTOTAL					$897,600				$1,146,000				$1,260,000
UTOPIA ROAD LATERAL													
East Fork Cave Creek to 30th St.	1,920	225	6'x4' BOX	$360	$691,200	433	11'x4' BOX	$540	$1,036,800	532	12'x4' BOX	$576	$1,105,920
30th St. to 32nd St.	1,450	184	5'x4' BOX	$324	$469,800	351	8'x4' BOX	$432	$626,400	431	11'x4' BOXES	$540	$783,000
SUBTOTAL					$1,161,000				$1,663,200				$1,888,920
TOTAL FOR EAST FORK					$28,805,589				$30,743,789				$31,930,389

Where drop structures are unacceptable, gabions buried under earth linings can provide a channel surface capable of withstanding higher velocities, while preserving a natural appearance.

Right-of-way is another area that was significantly affected by the multi-use aspect of the design. In most areas the design right-of-ways are wider than for a typical drainage structure of this design capacity. The wide right of way is needed to provide space for recreational improvements, as well as to accommodate sideslopes of 6:1 along the channel. The 12-foot wide freeboard sections on each side of the channel sideslopes can be used for native landscaping without compromising the hydraulic capacity of the channel.

Greenway Channel to Bell Road. (SHEET 5 OF 15) This portion of the Upper East Fork Cave Creek Channel empties into the proposed Greenway Channel at a confluence 650 feet west of 20th Street. From the confluence, it proceeds upstream in a northeasterly direction, through a curved transition, and then north parallel to the alignment of 20th Street. The alignment crosses Bell Road through 12 6-foot X 10-foot reinforced concrete box culverts. The geometry of this alignment has been selected to minimize disruption of existing neighborhoods while preserving acceptable geometry for the confluence with the Greenway Channel.

This reach which begins at the Greenway Channel and ends at Bell Road has a typical 150-foot bottom, is 6-foot deep, with 6:1 side slopes, and has a fourteen foot service access on each side. The total required right-of-way then for this reach is 250 feet.

An inlet structure south of Bell Road is needed for the confluence of Bell Road Lateral II and the Upper East Fork Cave Creek Channel.

No right-of-way exists in this area. Right-of-way will need to be purchased for this reach.

At the time of this writing, residential development is under construction. Though no utility conflicts existed before, possible conflicts might occur in the future.

Bell Road to Grovers Avenue. (SHEET 5 OF 15) Upstream of Bell Road, the channel alignment continues north for 1650 feet, and then enters a transition curve from which it emerges in a northeasterly direction. The upstream end of this section consists of two 11-foot X 6-foot reinforced concrete boxes which compose the outlet structure for Detention Basin #3. These boxes also allow the water to cross under Grovers Avenue.

A typical cross-section for this reach from Bell Road to Grovers Avenue consists of a 150-foot bottom width, a 6-foot depth, with 6:1 side slopes, and a 14-foot service access on each side. This makes for a total required right-of-way width of 250 feet.

There are no utility conflicts in this area. Additional 150' of right-of-way will need to be secured for this entire reach.

Detention Basin #3. (SHEET 15 OF 15) Just upstream from Grovers Avenue is Detention Basin #3. This basin encompasses 13.7 acres of surface area at the immediate northwest corner of the intersection between Grovers Avenue and Cave Creek Road. This location minimizes the need to remove or disturb existing structures, but the existing relatively steep ground slope across the basin presents hydraulic problems. To get the flow through this section without excessive velocities, and preserve existing street grades at Grovers Avenue and Cave Creek Road, the inlet and outlet structures have been designed to drop the flow vertically and discharge it at acceptable velocities. Thus, grade breaks are needed at the inlet and outlet pipe structures.

The outlet structure is made up of two 11-foot X 6-foot reinforced concrete boxes. These join two 10-foot X 6-foot reinforced concrete boxes at a grade break.

The inlets include two 12-foot X 6-foot reinforced concrete boxes from the open channel upstream of Cave Creek, and a 121-inch X 77-inch reinforced concrete elliptical pipe crossing Cave Creek Road from the Grovers Avenue Lateral.

There are no utility conflicts in the basin area.

There is no existing right-of-way except for the areas on the fringes that are dedicated to Grovers Avenue or Cave Creek Road. Additional right-of-way will have to be secured to allow for the design acreage listed above.

An alternate location for Detention Basin #3 is found at the southeast corner of 20th Street and Grovers. Either site can provide the required detention area.

Cave Creek Road to Union Hills Drive. (SHEET 12 OF 15) Between Cave Creek Road and Union Hills Drive is a section of existing channel that can carry the projected 100-year flows for this area. It is proposed to use this section of channel without further improvements.

This reach will also satisfy most of the multi-use design criteria. It deviates from the multi-use concept in that it is grass landscaped, but it provides adequate area and gentle enough slopes to allow for pedestrian and bike path facilities.

While right-of-way does not exist, there is a drainage easement through the area. This status may need to be changed.

Union Hills Drive to Utopia Road. (SHEET 12 OF 15) To pass under Union Hills Drive eleven 4-foot X 6-foot reinforced concrete box culverts are used. The drainage channel continues upstream from the boxes by meandering northward along the existing channel alignment, under Siesta Lane, to Utopia Road. Three 10-foot X 6-foot reinforced concrete box culverts are required to convey 100-year flows under Siesta Lane.

While disturbance of existing improvements was held to a minimum, several permanent structures and numerous mobile home trailers will have to be removed or relocated through this reach.

A critical utility conflict occurs under Siesta Lane where the concrete box culverts intersect a sanitary sewer line. This sewer needs to be raised over the boxes and encased in concrete.

The typical channel section has a 120-foot bottom, is 6.4 feet deep, with 6:1 side slopes, and 26.6-foot service and activity areas on the shoulders. This makes for a total required right-of-way of 250 feet.

Utopia Road to Beardsley Road. (SHEET 12 OF 15) A 12-foot X 6-foot reinforced concrete box culvert carries the main channel under Utopia Road and joins the Utopia Drive Lateral. The Upper East Fork Cave Creek continues upstream in a northerly direction, following the existing creek bed alignment to the outlet structure of Detention Basin #1.

A critical utility conflict is encountered under Utopia Road where the concrete box culvert crosses a sanitary sewer line.

A typical channel cross-section in this area consists of a 15-foot bottom, with a 6.6-foot depth, 6;1 side slopes, and 28-foot shoulder area. The required right-of-way is 150-feet. To obtain this right of way, it will be necessary to purchase property along the back side of several residential lots. Relocation of the homes along this channel is not anticipated.

Detention Basin #1. (SHEET 12 OF 15) The proposed location of Detention Basin #1 is the northeast corner of 26th Street and Beardsley Road. The outlet structure for Detention Basin #1 is a culvert under Beardsley Road. It consists of four 48-inch reinforced concrete pipes.

The basin consists of 18.4 acres of undeveloped land and is 6-foot deep.

No utility conflicts have been identified.

No right-of-way other than that dedicated to Beardsley Road exists.

Bell Road Lateral II. (SHEET 14 OF 15) This lateral consists of four reaches which run from the Upper East Fork of Cave Creek (20th Street) directly under the centerline of Bell Road to about 28th Street. Starting at the outlet where it joins the Upper East Fork of Cave Creek there are 1120 lineal feet of three 8-foot X 4-foot reinforced concrete boxes. Continuing east and upstream are 1300 lineal feet of two 6-foot X 4-foot reinforced concrete boxes, then 1340 lineal feet of two 5-foot X 4-foot reinforced concrete boxes, and finally 1320 lineal feet of a 7-foot X 4-foot reinforced concrete box. The box slopes through this lateral were designed to provide clearances over several sanitary sewers that cross the alignment.

The existing right-of-way for Bell Road in this area is sufficient.

20th Street Lateral. (SHEET 5 OF 15) Three reaches make up this lateral. First, a 900 lineal foot 60-inch reinforced concrete pipe, extends from its mouth at the proposed Upper East Fork of Cave Creek Channel to Grovers Avenue. The second and third reaches are 54-inch reinforced concrete pipe at different slopes to follow the topography. The total alignment follows the centerline of 20th Street.

Where no existing right-of-way exists, fifteen feet additional right-of-way will be required on the east side of the centerline on 20th Street south of Grovers Avenue.

A critical utility conflict exists where a sanitary sewer line under Grovers Avenue crosses over the lateral. While the two structures avoid each other, there is no clear distance between them. Therefore, the sanitary sewer will need to be encased in concrete for structural protection.

Grovers Avenue Lateral. (SHEET 15 OF 15) From its outlet to Detention Basin #3 (Cave Creek Road), this lateral runs easterly directly under the centerline of Grovers Avenue to about 29th Street. It consists of two reaches. The first reach consists of 1450 lineal feet of 121-inch X 77-inch reinforced concrete elliptical pipe. The second reach consists of 2000 lineal feet of 98-inch X 63-inch reinforced concrete elliptical pipe. Elliptical pipe was used to provide clear distance over a sanitary sewer that runs underneath Cave Creek Road and sufficient surface cover for the pipe itself. Also a second sanitary sewer further upstream under 28th Street limited the pipe diameter.

The Grovers Avenue right-of-way is adequate for this lateral.

Two critical utility conflicts exist. Both are sanitary sewer lines. By using an elliptical section, these conflicts have been avoided. However, clear distance is still at a minimum in both cases and infiltration and structural protection will have to be supplied.

Utopia Road Lateral. (SHEET 10 OF 15) From its outlet to the Upper East Fork of Cave Creek this lateral runs upstream and east under the centerline of Utopia Road to about 32nd Street. It has five reaches. The first and second reaches are composed of 12-foot X 4-foot reinforced concrete box with different slopes. The first reach is 1200 lineal feet and the second is 720 lineal feet. The last three reaches differ in slope only. They are composed of two 5-foot X 4-foot reinforced concrete boxes. Their lengths, continuing east, are 950 lineal feet, 250 lineal feet, and 250 lineal feet respectively.

A 60-inch waterline running under 32nd Street was avoided by altering the box slope. Otherwise, there are no utility conflicts.

The existing right-of-way for Utopia Road is sufficient for this lateral. No additional right-of-way is needed.

5. EAST AREA - GREENWAY CHANNEL OUTLET

The projects described in this section and their costs are summarized in Tables 6.5. Tables 6.5 also lists corresponding projects required to convey 50-year and 10-year floods, along with their costs.

Detention Basin #6. (SHEET 11 OF 15) This basin is the culmination point for both the East Area - Greenway Channel Outlet and the Greenway Channel Extension. It is located on the east side of Cave

TABLE 6.5

COST COMPARISON TABLE - EAST AREA

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
EAST AREA =========													
Detention Basin #6	20.5ac		R/W		$820,000		R/W		$1,600,000		R/W		$2,740,000
			Constr.		$475,000		Constr.		$884,000		Constr.		$942,590
Detention Basin #6 to 29th St.	1,750	673	Concrete Channel	$100	$175,000	1,144	Concrete Channel	$110	$192,500	1,374	Concrete Channel	$120	$210,000
	2.41ac		R/W		$800,000				$800,000				$800,000
29th St. to Phelps Rd.	1,700	373	12'x4' BOX	$576	$979,200	626	2-11'x4' BOXES	$1,080	$1,836,000	749	2-12'x4' BOXES	$1,152	$1,958,400
Phelps Rd. to Bell Rd.	750	373	8'x4' BOX	$432	$324,000	626	2-7'x4' BOXES	$792	$594,000	749	2-8'x4' BOXES	$864	$648,000
Bell Rd. to 32nd. St.	2,000	309	8'x4' BOX	$432	$864,000	519	12'x4' BOX	$576	$1,152,000	620	2-8'x4' BOXES	$864	$1,728,000
32nd. St. to Grovers Ave.	2,400	128	54" RCP	$216	$518,400	219	66" RCP	$264	$633,600	265	72" RCP	$288	$691,200
Grovers Ave. to Detention Basin #4	260	128	42" RCP	$174	$45,240	219	54" RCP	$216	$56,160	265	54" RCP	$216	$56,160
Detention Basin #4	13.7ac		R/W	$40,000	$548,000		R/W	$40,000	$548,000		R/W	$40,000	$548,000
			Constr.		$460,000		Constr.		$550,000		Constr.		$629,926
Detention Basin #4 to Culvert Outlet	1,550	140	Modify Ex Channel	$50	$77,500	272	Modify Ex Channel	$60	$93,000	336	Modify Ex Channel	$70	$108,500
Culvert under Union Hills Drive	770	100	7'x4' BOX	$396	$304,920	196	11'x4' BOX	$540	$415,800	243	12'x4' BOX	$576	$443,520
SUBTOTAL					$6,391,260				$9,355,060				$11,504,296

NBS/Lowry

COST COMPARISON TABLE - EAST AREA

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
PARADISE LANE LATERAL ====================													
29th St. to 33rd St.	2,460	183	7'x4' BOX	$396	$974,160	316	11'x4' BOX	$540	$1,328,400	378	12'x4' BOX	$576	$1,416,960
SUBTOTAL					$974,160				$1,328,400				$1,416,960

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
BELL ROAD LATERAL III ====================													
32nd St. to 36th St.	2,000	95	54" RCP	$216	$432,000	158	60" RCP	$240	$480,000	187	66" RCP	$264	$528,000
SUBTOTAL					$432,000				$480,000				$528,000

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	50 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)	100 YEAR FLOOD Q (cfs)	STRUCTURE	COST UNIT ($)	TOTAL ($)
GOLF COURSE LATERAL ==================													
Detention Basin to 38th St.	2,200	175	Earth Channel	$50	$110,000	364	Earth Channel	$50	$110,000	450	Earth Channel	$50	$110,000
38th St. to 39th St.	660	135	"	$40	$26,400	280	"	$40	$26,400	361	"	$40	$26,400
	5.05ac		R/W	$40,000	$202,000		R/W	$40,000	$202,000		R/W	$40,000	$202,000
SUBTOTAL					$338,400				$338,400				$338,400
TOTAL FOR EAST AREA					$8,135,820				$11,501,860				$13,787,656

NBS/LOWRY

TABLE 6.5 (Cont.)

Creek Road and fronts on the north edge of the proposed Greenway Road alignment. It encompasses 25.3 acres and is 8-foot deep. It drains into the Greenway Channel through three 10-foot X 6-foot reinforced concrete box culverts which pass diagonally under the intersection of Cave Creek Road and the proposed Greenway Road alignment.

There is no right-of-way in the area. To obtain the required acreage, several homes will need to be relocated.

There is a 30-inch diameter sanitary sewer that runs underneath the basin in a north-south direction. Relocation or cement slurry backfill will be required to protect this sewer. An 8" VCP under 26th Street will need to be relocated.

Paradise Lane Alignment: Detention Basin #6 to 29th Street. (SHEET 11 OF 15) This reach consists of 1750 lineal feet of concrete lined open channel. Starting at the east end of Detention Basin #6, it runs upstream and east along the extension of the Paradise Lane centerline. A typical cross-section consists of a 20-foot bottom width, 2:1 side slopes, a 6-foot depth, and an 8-foot shoulder access on each side.

The required right-of-way is 60-foot. To obtain this amount of right-of-way, several residential buildings will require purchase or relocation.

There are two sanitary sewers that run perpendicular to and underneath the channel bed. One of these sewers will have to be lowered. Both of them should be concrete encased.

29th Street: Paradise Lane to Bell Road. (SHEET 6 OF 15) There are two reaches that make up this section. The first is composed of 1700 lineal feet of two 12-foot X 4-foot reinforced concrete boxes.

The second consists of 750 lineal feet of two 8-foot X 4-foot reinforced concrete boxes. These boxes run parallel to and two feet to the west of the centerline of 29th Street throughout their length. They empty into the open channel structure at the Paradise Lane intersection, and receive their flow from the upper reach of pipe under Bell Road.

There is a critical utility conflict with a sanitary sewer line in the lower reach. This sewer is a dead end reach with minimal service and therefore easily relocated.

The existing 29th Street right-of-way is sufficient for this storm drain.

Bell Road: 29th Street to 32nd Street. (SHEET 14 OF 15) This reach consists of 2000 lineal feet of two 8-foot X 4-foot concrete boxes aligned two feet north of centerline in Bell Road. For priority number 1, a temporary alignment of 720 lineal feet in Bell Road will connect this reach with the proposed Bell Road Lateral II.

No utility conflicts or additional right-of-way affects this reach.

32nd Street: Bell Road to Grovers Avenue. (SHEET 6 OF 15) This reach is made up of 2400 lineal feet of 72-inch diameter reinforced concrete pipe. It runs parallel to and 30-foot to the west of the centerline of 32nd Street. It discharges into a box structure under Bell Road and receives its flow from the outlet structure of Detention Basin #4.

No critical utility conflicts have been identified throughout its length.

The 32nd Street right-of-way is adequate for this storm drain.

Detention Basin #4. (SHEET 6 OF 15) This basin is located at the northeast corner of the intersection of Grovers Avenue and 32nd Street. It contains 13.7 acres and is 6-foot deep. It drains to a single 54-inch diameter reinforced concrete pipe that enters into a 72-inch diameter pipe under 32nd Street. It receives inflow from an existing open channel on the east side of 32nd Street north of the basin, and a new open channel from the golf course to the west. To use the existing channel to the north, a drop structure will have to be constructed at its inlet. The drop structure will be more cost effective than to regrade the channel and incorporate similar drop structures upstream.

No utility conflicts have been identified in this area.

Storm Drainage right-of-way will need to be obtained or designated for the entire area. Parts of this site are currently owned by Maricopa County and the North Valley Education Center.

Detention Basin #4 (Grovers Avenue) to Union Hills Drive. (SHEET 6 OF 15) This section of the drainage structure is composed of two existing reaches of detention basin that are connected via 2 new 10-foot X 4-foot reinforced concrete boxes that convert them into one earthlined open channel. The boxes are located under an entrance drive that services the property to the east from 32nd Street. A typical cross-section for the channel is composed of a 28-foot bottom, a 3.4-foot depth, and 4:1 side slopes. It runs upstream from its outlet at detention Basin #4 north to about Union Hills Drive on an alignment parallel to the centerline of 32nd Street and 90-foot east of it.

A 12-foot X 4-foot concrete box culvert under Union Hills Drive is recommended to intercept flow from north of Union Hills Drive.

Since this stretch is made up of modified existing features there are no utility interferences.

An additional 70-foot of right-of-way will be required immediately east of the existing 32nd Street right-of-way to adequately encompass this reach of drainage structure.

Paradise Lane Lateral. (SHEET 11 OF 15) This lateral contains three reaches of box culverts, running upstream from 29th Street, where they discharge into the East Area - Greenway Channel Outlet. Throughout this distance they run at a 5-foot offset south of the centerline of Paradise Lane. All three reaches consist of a single 12-foot X 4-foot reinforced concrete box. They differ in slope to avoid utility conflicts.

While many utilities present possible conflicts for this lateral, only two are critical. The first is a sanitary sewer line that crosses lateral near 29th Street. It will have to be relocated. The second is a 36-inch waterline that runs under 32nd Street. It will need to be lowered.

There is no additional right-of-way required for this lateral. The existing Paradise Lane right-of-way will be sufficient.

Bell Road Lateral III. (SHEET 14 OF 15) This lateral consists of a single reach of drainage structure. It will drain into the East Area - Greenway Channel Outlet at 29th Street and Bell Road. From there it runs upstream and east, two feet north of the centerline under Bell Road. It consists of 2000 lineal feet of 66-inch reinforced concrete pipe.

An additional 660 feet of 66-inch reinforced concrete pipe between 28th Street and 29th Street will need to be constructed, as an interim measure until the Greenway Channel outlet is completed. This will allow the Bell Road Lateral III to temporarily drain into the Bell Road Lateral II.

No utility conflicts have been identified for this lateral.

The existing right-of-way for Bell Road in this area is sufficient for this pipeline.

Golf Course (Grovers Avenue Alignment) Lateral. (SHEET 15 OF 15) This portion of the drainage structure consists of two reaches of earth-lined open channel. It runs upstream, from its outlet at Detention Basin #4, west across the Paradise Valley Park Golf Course to the south boundary of the golf course, following the boundary for 1350 feet. Overland flow is collected into the channel throughout its length as it travels across the golf course. The first reach is 1500 lineal feet and the second is 700 lineal feet. A typical cross-section is made up of a 8-foot bottom, a 6-foot depth, with 6:1 side slopes, and 10-foot shoulder access areas on each side.

No critical utility conflicts have been identified.

Additional right-of-way will have to be obtained throughout the channel length. This right-of-way will consist of the south 100 feet of the golf course. A 100' wide right-of-way will be needed in the south area of the golf course.

6. GREENWAY CHANNEL EXTENSION (SHEET 11 OF 15)

Table 6.6 lists the various projects described in this section, and their estimated costs. Also included in Table 6.6 are the costs of downsized facilities to carry 50-year and 10-year storm events.

Three reaches of concrete box culvert make up the Greenway Channel Extension. All reaches follow the centerline of the proposed Greenway Road Alignment per the "Greenway Road Location Study" performed for the City of Phoenix (P-820357) by Dibble and Associates. The project runs upstream from Detention Basin #6 to just east of 29th Street.

The first reach is composed of two 12-foot X 4-foot reinforced concrete boxes and extends for 1430 lineal feet. The second reach is made up of two 11-foot X 4-foot reinforced concrete boxes and is 750 lineal feet in length. The third reach also consists of two 11-foot X 4-foot reinforced concrete boxes, and is 1050 lineal feet in length.

There are two critical utility conflicts along this lateral. Both are sanitary sewers. One may have to be relocated, to avoid intersecting the lateral. The second will require concrete encasement for structural and infiltration protection.

If the proposed alignment for Greenway Road is used it will provide adequate right-of-way for this structure.

7. SOUTH AREA GREENWAY CHANNEL OUTLET (SHEET 13 OF 15)

This project is composed of four reaches. The project carries flow from two inlets, located in the area of Everett Drive and 21st Way, to the Greenway Channel. The alignments and structures themselves

COST COMPARISON TABLE - GREENWAY CHANNEL EXT.

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
GREENWAY CHANNEL EXT.													
Detention Basin #6 to 27th St.	1,430	387	12'x4' BOX	$576	$823,680	653	2-11'x4' BOXES	$1,080	$1,544,400	771	2-12'x4' BOXES	$1,152	$1,647,360
27th St. to 29th St.	1,800	257	11'x4' BOX	$540	$972,000	428	2-11'x4'	$1,080	$1,944,000	508	2-11'x4' BOXES	$1,080	$1,944,000
TOTAL GRNWY CHNL. EXT.					$1,795,680				$3,488,400				$3,591,360

vary greatly and are therefore addressed below individually. Table 6.7 summarizes the projects described in this section and their costs. Downsized facilities required to carry 50-year and 10-year flows only, are also identified in Table 6.7.

Greenway Channel to Waltann Lane. The first reach consists of 1250 lineal feet of concrete lined open channel, which follows the course of an existing drainageway from its outlet at the Greenway Channel to its intersection upstream of Waltann Lane. In between, the channel crosses under Monte Cristo Avenue using three 12-foot X 6-foot reinforced concrete box culverts. The channel has a bottom width of 30 feet, a depth of 7 feet, side slopes of 1:1, and a service access way on each side of 8 feet.

Since the channel, as planned, follows the alignment of an existing drainage way, there is a corresponding drainage easement in place at this time. The status of this easement may need to be changed to that of a dedicated right-of-way.

There is a critical utility conflict with a sanitary sewer line underneath Monte Cristo Avenue. This sewer will have to be relocated.

Waltann Lane to Greenway Road. This reach consists of 1220 lineal feet of two 10-foot X 8-foot reinforced concrete boxes. They inlet from two smaller boxes at Greenway Road and transport the flow to the open channel reach below. Their alignment varies as they wind their way along Waltann Lane, paralleling an existing sewer line.

There is a sanitary sewer line that crosses over the boxes in this area. Structural protection will need to be provided for these in the form of a concrete saddle or similar device.

There are no additional right-of-way requirements for this area.

COST COMPARISON TABLE - SOUTH AREA

DESCRIPTION	LENGTH (ft)	10 YEAR FLOOD Q (cfs)	10 YEAR FLOOD STRUCTURE	10 YEAR FLOOD COST UNIT ($)	10 YEAR FLOOD COST TOTAL ($)	50 YEAR FLOOD Q (cfs)	50 YEAR FLOOD STRUCTURE	50 YEAR FLOOD COST UNIT ($)	50 YEAR FLOOD COST TOTAL ($)	100 YEAR FLOOD Q (cfs)	100 YEAR FLOOD STRUCTURE	100 YEAR FLOOD COST UNIT ($)	100 YEAR FLOOD COST TOTAL ($)
SOUTH AREA ==========													
Greenway Channel to Waltann Lane	1,250	1,004	Modify Ex Channel	$120	$150,000	1,655	Modify Ex Channel	$120	$150,000	1,953	Modify Ex Channel	$120	$150,000
Waltann Lane to Greenway Rd.	1,220	1,004	2-8'x6' BOXES	$1,080	$1,317,600	1,655	2-10'x7' BOXES	$1,344	$1,639,680	1,953	2-10'x8' BOXES	$1,460	$1,781,200
Greenway Rd. to 21st Way	1,500	784	11'x6' BOX	$648	$972,000	1,277	2-9'x6' BOXES	$1,152	$1,728,000	1,503	2-10'x6' BOXES	$1,224	$1,836,000
21st Wy. to 21st Pl.	1,420	614	8'x6' BOX	$540	$766,800	1,000	11'x6' BOX	$648	$920,160	1,173	12'x6' BOX	$684	$971,280
	1.72ac		R/W	$40,000	$68,800		R/W	$40,000	$68,800		R/W	$40,000	$68,800
TOTAL FOR SOUTH AREA					$3,275,200				$4,506,640				$4,807,280
**** GRAND TOTAL ****					$54,379,569				$68,109,869				$74,306,945

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TABLE 6.7

22nd Street:Greenway Road to 21st Way. 1500 lineal feet of two 10-foot X 6-foot reinforced concrete boxes make up this reach of the drainage structure. It lies under 22nd Street at an offset distance of 5 feet east of centerline.

No critical utility conflicts have been found for this reach.

The existing 22nd Street right-of-way is sufficient for this reach.

Everett Drive to 22nd Street. This reach is composed of 1120 lineal feet of a 12-foot X 6-foot reinforced concrete box. It is aligned under 21st Way at a 5-foot offset to the southeast. It continues upstream, past the end of 21st Way (at Claire Drive) under the alignment of an existing drainage channel, to Everett Drive.

At Everett Drive the structure has two inlets. The first is located at the box's intersection with Everett Drive, where it receives the flow from an existing drainage channel. The second is located to the west of Everett Drive. The flow from this second or west inlet is carried to meet the flow of the first inlet via 300 lineal feet of 12-foot X 6-foot reinforced concrete box.

No additional right-of-way is needed in the areas where the structure runs underneath 21st Way or Everett Drive. However, in the areas where existing drainage channel alignments are utilized, only drainage easements exist. It may be desirable to change this status in the future.

A critical utility conflict exists with a sanitary sewer in the area of the intersection between 21st Way and 22nd Street. While this sewer avoids contact with the box it has no clear distance. It will need to be protected.

CHAPTER 7

PHASING AND IMPLEMENTATION

INTRODUCTION

Chapter 6 presented a description of the various recommended projects included in the Upper East Fork Cave Creek Preliminary Area Drainage Master Plan. This chapter contains recommendations for budgetary and construction phasing.

For budgeting purposes, capital improvements must be prioritized and constructed in phases as funding permits. To identify phasing of the proposed storm drainage improvements for this area, three priority categories were used. Priority No. 1 is used to indicate those projects that are recommended for construction within the next 5 years. Similarly Priority No. 2 indicates those parts of the drainage structure that are recommended for construction in the next 5 to 10 years. Priority No. 3 indicates those projects that are recommended for construction after this initial 10 year period.

Tables 7.1, 7.2 and 7.3 summarize each of the master plan projects and their construction cost in 1987 dollars by priority.

Priorities have been assigned only as a guide to the relative urgency of the storm drainage improvements. They are subject to revision for various reasons. For instance, in the next few years changes may occur in the drainage areas development patterns. The current financial obligations of government agencies or that of land developers may also vary. Further, as scheduling of roadway construction in the area becomes clearer, significant savings may be achieved by coordinating storm sewer construction with that of the roads or highways.

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The different projects considered as Priority No. 1 have been listed with a brief discussion of their priority qualifications. Those remaining projects that have been designated as Priority No. 2 or Priority No. 3 have simply been listed along with their estimated project costs in 1987 dollars.

Each priority phase as proposed has been drawn up schematically in Figures 7.1, 7.2, and 7.3 respectively. Each progressive figure shows existing drainage facilities or phases of earlier proposed improvements, as well as those projects included in that particular phase.

PRIORITY NO. 1

Figure 7.1 shows the Priority No. 1 projects. The estimated cost of these projects is $39,787,587.

Greenway Channel. All projects within the Upper East Fork Cave Creek watershed eventually drain into the Greenway Channel. This channel must therefore be designed and constructed first. Portions of this channel are now constructed or under construction. Other portions have been designed. Completion of this channel is necessary so that the remaining projects can be added as soon as possible.

9th Street - Greenway Channel Outlet & Detention Basin's No. 2 & No. 5. 9th Street is known to be an area that experiences major flooding problems even during small frequency storms. While it is not in the Upper East Fork Cave Creek floodway, the damage and inconvenience that would be experienced in this area, in the event of a major runoff event, would be most excessive and unacceptable. These detention basins will mitigate storm damage along 9th street, along with helping to keep the Upper East Fork Cave Creek Watershed discharges below the design flows for the Arizona Canal Diversion Channel (ACDC).

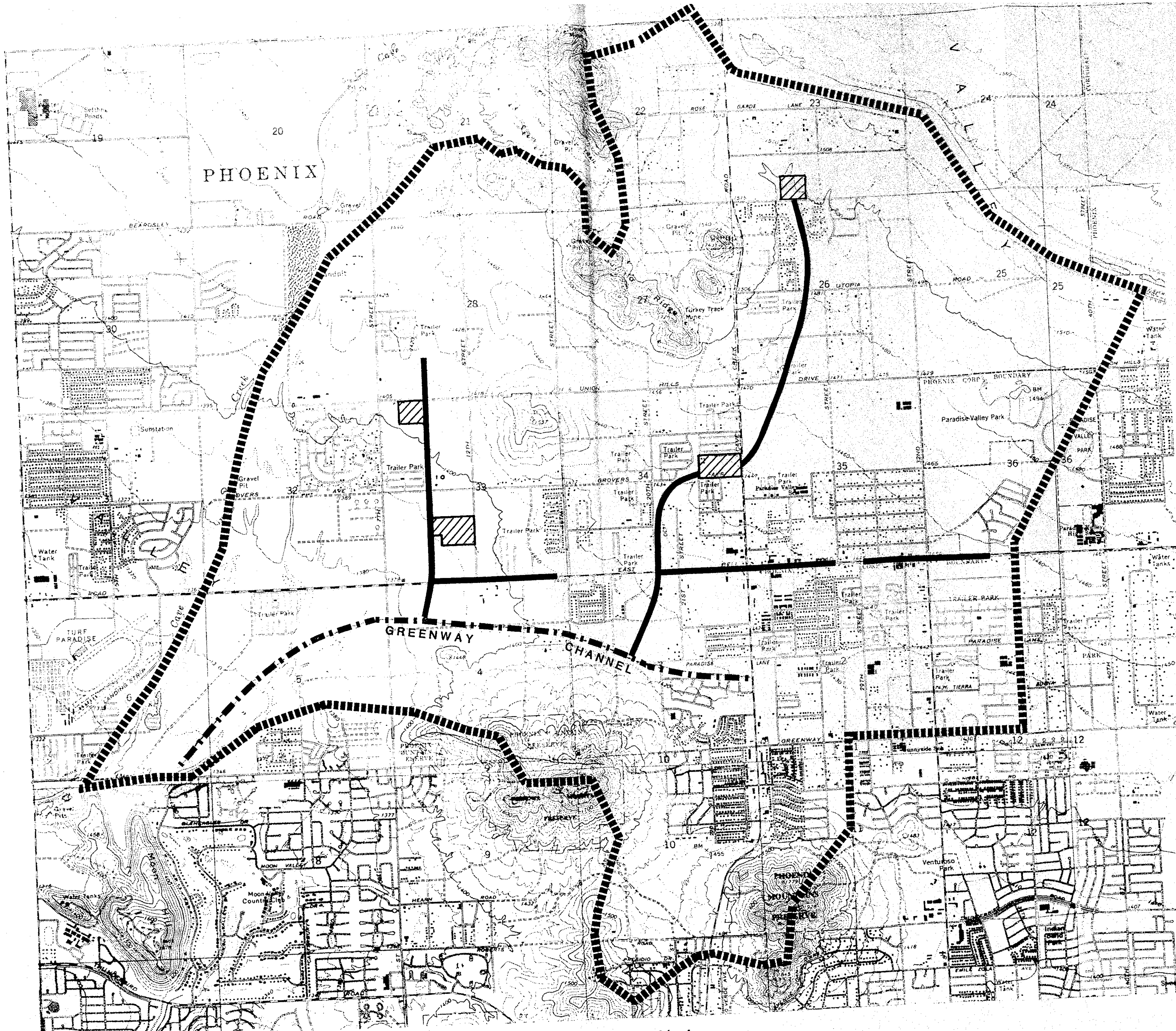

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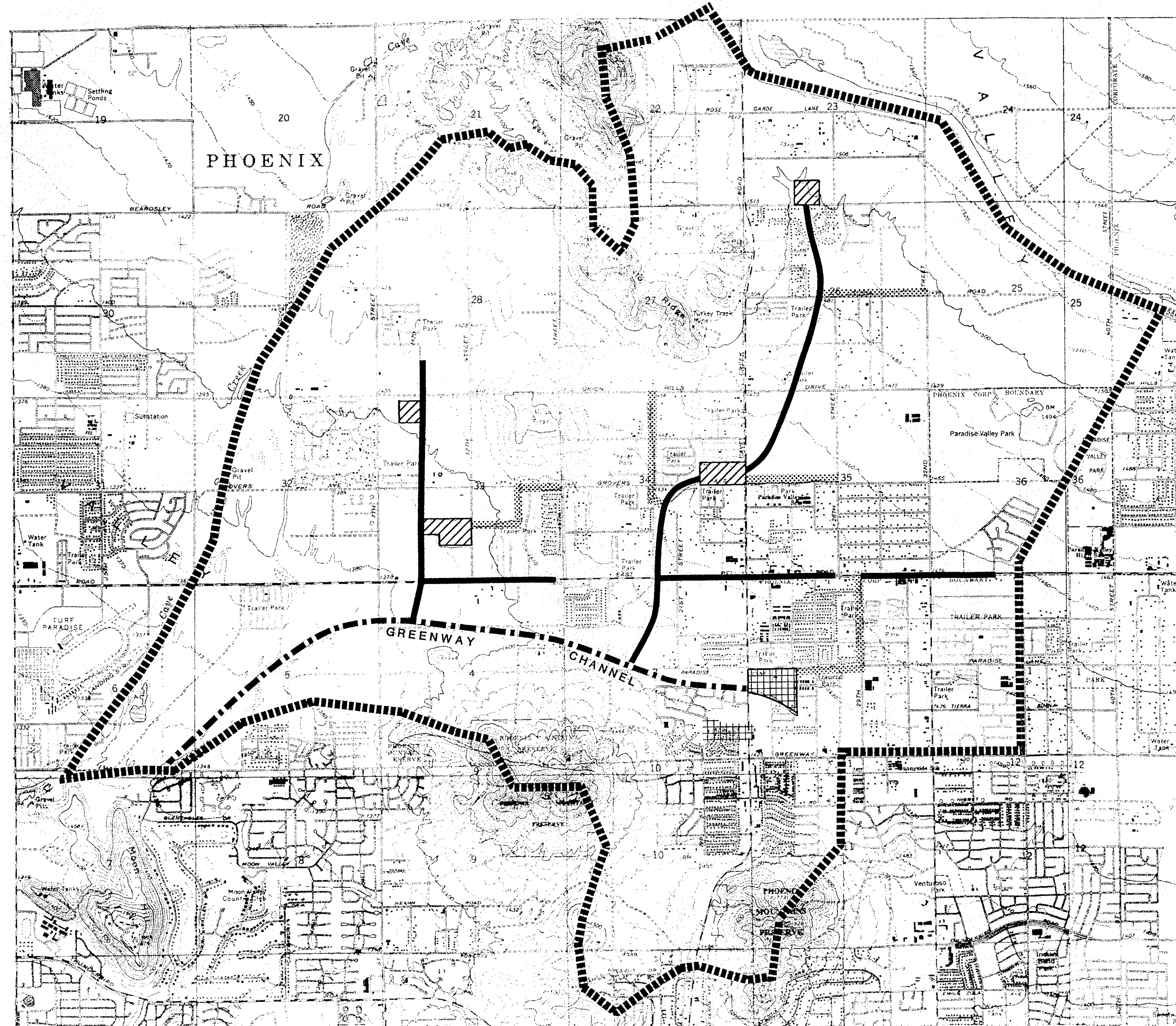
FIGURE 7.1

PRIORITY 1



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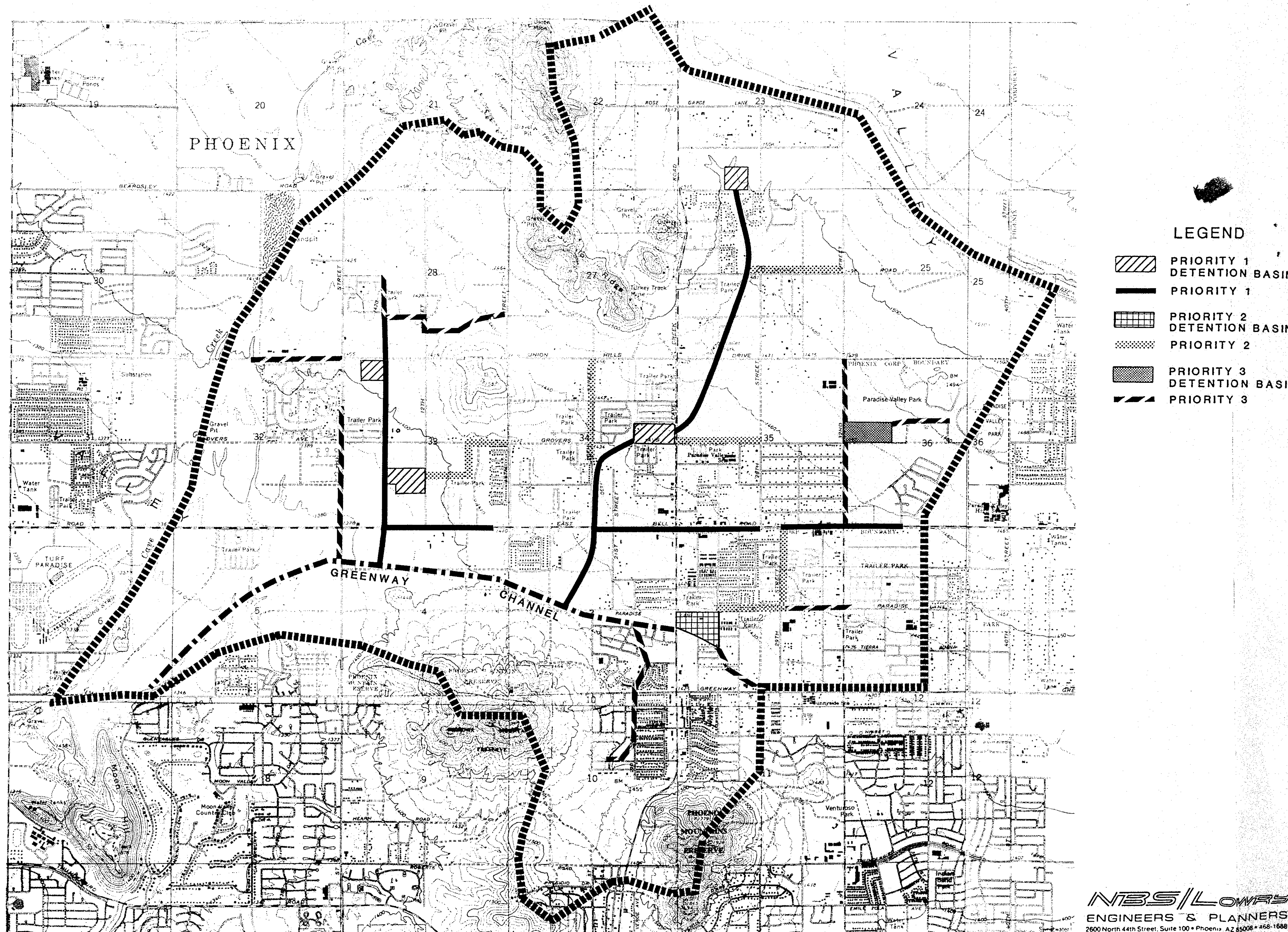
PRIORITY 2

FIGURE 7.2



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PRIORITY 3

FIGURE 7.3

It is important that land be acquired for these two detention basins now, before other improvements are constructed on these lands, and the property becomes unavailable or unaffordable.

Upper East Fork Cave Creek & Detention Basin's No. 1 & No. 3. The areas immediately adjacent to the proposed Upper East Fork Cave Creek channel represent the most serious flood risk within the Upper East Fork Cave Creek watershed at this time. Channelization and detention will control this risk, and can permit reclaiming some properties now within FEMA floodways for beneficial use.

East Area Greenway Channel Outlet / Bell Road: 29th Street to 32nd Street & Bell Road Lateral's I, II, & III. All of these segments are within the alignment of Bell Road. Bell Road is scheduled for widening and reconstruction by the Maricopa County Highway Department and the City of Phoenix within the next 5 years. Large construction cost savings may be realized for these drainage projects if their construction can be incorporated into the roadway construction work on Bell Road.

Right-of-Way. Development in the drainage area is proceeding at an alarming rate. Several parcels of land that were looked at at one time as sites for various drainage system elements have since been developed. Areas proposed in this report for drainage improvements may also soon be developed if required right-of-way is not acquired now. Therefore, any right-of-way that is needed for Priority No. 1 alignments, or for the future construction of Priority No. 2 or Priority No. 3 projects, should be purchased at this time.

ESTIMATED COST IN 1987 DOLLARS

PRIORITY NO. 1

PROJECT	COST
Greenway Channel	Cost Not Included
9th St. - Greenway Channel Outlet	$ 8,458,040
Upper East Fork Cave Creek	$24,225,309
East Area - Greenway Channel Outlet Bell Road 29th St. to 32nd St. & Bell Road's Laterals I, II & III	$ 7,104,240
TOTAL PRIORITY NO. 1	$39,787,587

TABLE 7.1

PRIORITY NO. 2

Priority No. 2 projects are those projects that can be deferred for approximately 5 years. Figure 7.2 shows the Priority No. 2 projects. These projects, and their costs, are shown on Table 7.2.

The total cost of these projects is estimated to be $13,691,030.

PRIORITY NO. 2

PROJECT	COST
Campo Bello - 14th St. - Grovers Ave. Lateral	$ 2,465,520
20th St. Lateral	$ 777,600
Grovers Ave. Lateral	$ 1,260,000
Utopia Road Lateral	$ 1,888,920
East Area - Det. Basin #6 to Bell Road	$ 7,298,990
TOTAL PRIORITY NO. 2	$13,691,030

TABLE 7.2

PRIORITY NO. 3

Priority No. 3 projects are those projects which can be deferred for more than 5 years. These Priority No. 3 projects are shown on Figure 7.3. The projects and their costs are shown on Table 7.3.

The total cost of these Priority No. 3 projects is estimated to be $20,828,326.

PRIORITY NO. 3

PROJECT	COST
Union Hills - Cave Creek Outlet	$ 3,407,400
7th St. - Bell Road to Michigan Road	$ 1,582,260
Morrow Drive Lateral	$ 3,207,360
South Area - Greenway Channel Outlet	$ 4,807,280
East Area - 32nd St: Bell Road to Union Hills	$ 2,477,306
Paradise Lane Lateral	$ 1,416,960
Golf Course Lateral & Detention Basin #4	$ 338,400
TOTAL PRIORITY NO. 3	$20,828,325
TOTAL PRIORITIES 1, 2 & 3	$74,306,945

TABLE 7.3

NBS/Lowry

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